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Environmental Impact Statement
Municipality of Metropolitan
Seattle Sludge Management Plan

Jones and Stokes Associates, Inc.
Sacramento, CA

Prepared for

Environmental Protection Agency
Seattle, WA

Apr 83

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Environmental Impact Statement

Draft

Municipality of Metropolitan Seattle Sludge Management Plan

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16. ABSTRACT

The Municipality of Metropolitan Seattle (Metro) has identified four broad categories of sludge management alternatives to be pursued over the next 15-20 year planning period. The categories include composting, application to silviculture lands, application to agriculture lands and soil improvement. The Draft EIS identifies and evaluates potential impacts of these alternatives to geology, soils, public health, surface and groundwater quality, land use, vegetation and crops, terrestrial wildlife and aquatic life. Recommended mitigation measures are described. Also included is a detailed analysis of a proposed demonstration project on 72 acres of forest land in Western Washington.

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APR 8 1983

REPLY TO
ATTN OF: M/S 443

TO: All Interested Government Agencies, Public Groups and Citizens

Enclosed for your review and comment is the Draft Environmental Impact Statement (EIS) on the proposed Municipality of Metropolitan Seattle (Metro) Sludge Management Plan. The Environmental Protection Agency (EPA) has given Metro a grant for the planning phase of this project under Section 201 of the Clean Water Act. EPA has prepared this Draft EIS on its proposed approval of Metro's Plan pursuant to Section 102(2)(c) of the National Environmental Policy Act (NEPA) of 1969 and implementing Federal regulations.

In addition, in order to avoid duplication of effort and unnecessary expense, this Draft EIS is also intended to meet the requirements of the State of Washington Environmental Policy Act (RCW 43.21C).

EPA will announce the availability of this document in the Federal Register on Friday, April 15, 1983, which will begin a 45-day review period. If you have any comments on the Draft EIS or wish to provide additional information for inclusion in the Final EIS, we would appreciate hearing from you before the close of the comment period on May 31, 1983. All comments received will be used by Environmental Protection Agency in evaluating the effects of approving the Plan.

Please send your comments to:

Kathryn Davidson
Environmental Evaluation Branch M/S 443
Environmental Protection Agency
1200 Sixth Avenue
Seattle, Washington 98101

Public hearings on the Draft EIS and Metro's Draft Plan will be held in Seattle at the Federal Building, 915 Second Avenue, on May 17, 1983 and at the Arlington Middle School in Arlington, Washington, on May 19, 1983. Both hearings will begin at 7:30 p.m. Public information meetings will be held in Seattle on May 3, 1983 and in Arlington on May 5, 1983 at the same locations and times.

DRAFT
ENVIRONMENTAL IMPACT STATEMENT

MUNICIPALITY OF METROPOLITAN SEATTLE
SLUDGE MANAGEMENT PLAN

Prepared by:

U.S. Environmental Protection Agency
Region 10
1200 Sixth Avenue
Seattle, WA 98101
Kathryn Davidson, Project Officer

With Technical Assistance from:

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April 1983

Responsible Official;

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John R. Spencer
Regional Administrator

April 1, 1983
Date

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EXECUTIVE SUMMARY

(X) Draft Environmental Impact Statement
( ) Final Environmental Impact Statement
Type of Action: Administrative

Purpose and Need for Action

On October 21, 1980, Metro applied to Washington State Department of Ecology (DOE) for an amendment to the Step 1 construction grant for upgrading the Renton Treatment Plant. The amendment will cover planning for ultimate disposal of sewage sludge from the Metro system. The original Renton facilities plan included an element for removal of Renton's sludge from Metro's West Point Treatment Plant, where it is now sent for processing, and construction of processing facilities at Renton. This will fulfill a commitment, made in earlier facility planning efforts, to remove Renton sludge from West Point and thereby reduce the load on West Point facilities. However, the Renton plan did not cover ultimate sludge disposal. Planning for sludge disposal has proceeded within Metro as a separate effort to the Renton facilities plan. Since the U. S. Environmental Protection Agency (EPA) and Washington DOE had previously considered sludge disposal to be a logical part of Renton planning, and since Renton planning was already on the state priority list, sludge disposal planning was made an amendment to the existing grant rather than a separate grant. The EPA Environmental Impact Statement (EIS) for the Renton facilities plan discusses proposed sludge processing facilities at Renton and the impacts of construction and operation. The EIS also briefly summarizes ongoing Metro planning for sludge disposal, but does not analyze environmental impacts of disposal. Agreement was reached between Metro and EPA, prior to the grant amendment request, that EPA would prepare a separate EIS on sludge disposal.

Metro has prepared a sludge management plan for the following reasons: 1) a plan for sludge use is important to ensure proper treatment design at the Renton Treatment Plant; 2) Metro's 1980 facilities plan for the Renton Treatment Plant did not include a comprehensive evaluation of sludge management and disposal; 3) a sludge management plan is a required component of the National Pollutant Discharge Elimination System (NPDES) permit requirement for the Renton and West Point Treatment Plants; 4) future capacities to recycle or dispose of sludge through the year 2000 need to be assured; and 5) Metro needs to identify a cost-effective means of managing sludge.

Although federal funding has been used for preparation of the sludge management plan, no federal funding is anticipated for design or construction of the sludge processing or application facilities or for any proposed facilities upgrading at the Renton Treatment Plant (Riley pers. comm.).

Role of Environmental Impact Statement

This EIS focuses on two distinct facets of Metro's sludge management plan: the environmental impacts of Metro's sludge management alternatives, and the environmental impacts of Metro's proposed sludge application demonstration program on forestlands of the Pilchuck Tree Farm, Arlington, Washington. EPA has determined that this EIS is required to meet the requirements of the National Environmental Policy Act (NEPA). This EIS will also satisfy Metro's responsibilities under the Washington State Environmental Policy Act (SEPA) (RCW 43-21C).

Description of Alternatives

Background

From 1965 to 1972, Metro discharged sewage sludge through the West Point effluent outfall into Puget Sound. That method of sludge disposal was terminated in 1972 as a result of federal and state regulations prohibiting the ocean disposal of sludge. From 1973 on, Metro initiated a program of land application of sludge on demonstration and research sites throughout western Washington, and a composting program with GroCo, Inc. Among the research projects were forestland application at the University of Washington's Pack Research Forest, Eatonville, Washington, and agricultural application at Mt. Vernon and Puyallup, Washington. Results of Metro's forestland sludge application research have provided insight into seedling growth and survival, tree growth in established forests, and impacts of sludge constituents.

During the past 5 years, the volume of sludge generated at Metro's Renton and West Point Treatment Plants has increased approximately 85 percent. Approximately 49 percent of all sludge generated during the past 3 years has been applied as a top dressing at the Cedar Hills landfill, 32 percent has been transported to WIDCO for use in reclaiming surface-mined lands, and the remaining 19 percent has been utilized for either composting at GroCo, Inc., or land application at the Pack Research Forest, at the Duvall and Midway landfills, and at a number of small soil improvement sites in the King County area.

Metro projects that the quantity of sludge will increase from 35 dry tons of digested sludge per day in 1982 to slightly over 60 dry tons per day in 1990, and to 80 dry tons per day by the year 2000 (Metro 1983a). The physical, chemical, and microbial quality of the sludge has been extensively studied by Metro. An intensive monitoring program was carried out from May 1981 to May 1982 to determine the concentrations of nutrients, trace metals, trace organics, and bacteria in the sludge, and to provide insight into possible constraints that sludge quality may create for different management alternatives. Results of those studies are discussed in Chapter 2.

Long-Range Sludge Management Alternatives

Metro initially identified 18 project alternatives within eight broad categories of sludge management: agricultural application, composting, dry sludge product, incineration, landfilling, ocean disposal, silviculture, and soil improvement. Of the 18 initial alternatives, Metro eliminated five from further consideration because of high costs or unacceptable nonmonetary factors. Metro also "deferred" four other alternatives as not presently feasible for near-term implementation, but which might at some later date be more closely considered.

The remaining 9 alternatives were recommended by Metro for additional evaluation. These alternatives were:

- o Agricultural application
  - Alternative 1
- o Composting
  - Alternative 2A - tank composting
  - Alternative 2B.1 - pile composting, 18 percent solids
- o Silvicultural application
  - Alternative 7A - public/private forestlands with Metro-owned demonstration site
  - Alternative 7B - Metro-owned poplar forestlands
  - Alternative 7C - Metro-owned multiple use forestlands
  - Alternative 7D - public/private forestlands with Metro-owned backup site
- o Soil improvement
  - Alternative 8A - soil improvement of public/private land
  - Alternative 8B - soil improvement at WIDCO

Although 9 of 18 original alternatives were identified as "recommended", Metro's sludge management plan did not identify any single specific alternative, or any single combination of alternatives, as preferred. Rather, Metro identified land application of sludge through agricultural application, composting, silvicultural application and/or soil improvement to be the preferred management strategy. Metro further recommended that anaerobic digestion with medium dewatering (18 percent solids) be the preferred sludge processing method at both the Renton and West Point Treatment Plants.

This EIS focuses on the impacts of the preferred strategy (agricultural application, composting, silvicultural application, soil improvement) and the impacts of the 9 project alternatives previously described. The no-project alternative is also evaluated, as required by EPA regulations.

Near-Term Plan

As components of the 20-year planning effort, Metro has identified the need for 5-year and 1-year sludge management plans. The goal for sludge utilization during the 5-year planning period was as follows:

Agricultural application	15 percent
Composting	15 percent
Silvicultural application	25 percent
Soil improvement	45 percent

Because a specific 5-year plan has not yet been completed by Metro, it has not been evaluated in this Draft EIS.

Metro's proposed 1-year (1983) plan would include the use of five sites which have been granted requisite permits (WIDCO, Pack Forest, GroCo, and Cedar Hills and Duvall landfills), the Pilchuck demonstration project (permitting in progress), and other unidentified sites to accommodate the estimated 77,700 wet tons of sludge to be produced in 1983. The five permitted sites are not evaluated in this EIS because they have been previously evaluated to meet SEPA requirements, and because no federal funding for these sites is proposed. A detailed analysis of impacts associated with sludge application on the Pilchuck demonstration project has been included in the EIS.

Subsequent Metro Planning

Metro has indicated that more detailed sludge management planning will be undertaken during the time period of the draft and final sludge management plans (Metro letter to DOE December 20, 1982). Additional information in the final plan is to include the following elements:

- 1984 sludge utilization goal
  - Where possible sites, hauling distances, acreages, and application rates would be identified
- 1984-1988 sludge utilization goal
  - A more detailed description of the 5-year plan would be provided

- Year 2000 sludge utilization goal
  - Metro would recommend sludge utilization targets to the year 2000
  - The plan will outline criteria for achieving long-term commitments for use of Metro Sludge
- Contingency plan
  - The final plan would include the possibility of using Cedar Hills landfill or construction of a sludge storage lagoon
- Financial plan
  - This section will estimate the level of effort required to implement the 1983, 1984, 5-year, and year 2000 utilization goals and the contingency plan
- Public involvement
  - A discussion of procedures Metro will follow for future sludge utilization sites will be presented

Assessment of Impacts

The environmental impacts and potential mitigation measures of the four broad sludge management categories (agricultural application, composting, silvicultural use and soil improvement) are summarized in Tables S-1 through S-3. Only the more significant impacts have been summarized. The mitigation measures listed are possible methods of avoiding or reducing the severity of adverse impacts, but are not necessarily those that would be implemented should a project be constructed. The adopted mitigation measures will be included in EPA's Record of Decision on the project which will be prepared after completion of the Final EIS. EPA will not be responsible for all mitigation measures required. Local and state agencies will suggest or require those mitigations that are within their respective functional capacities.

An analysis of the impacts associated with the Pilchuck demonstration project is also presented following the assessment of impacts of the long-range options.

As part of the planning regulatory process, Metro would need to obtain permits and approval from a variety of state and local entities. A list of those permit requirements is presented in Table S-4.

Impacts of No Action

The "no-action" alternative would essentially mean that Metro would continue year-by-year planning which would create a situation whereby Metro may not have adequate flexibility and contingencies in the event established sludge application sites could no longer be utilized. Additionally, the NPDES permit which requires an approved sludge management plan would not be met.

Table S-1. Impacts of Sludge Processing and Transportation

Type of Impact	Description of Impact	Mitigation Measure
Site impacts at Renton treatment plant	These impacts were previously analyzed in EPA's EIS on the Wastewater Management Plan for the Lake Washington/Green River Basins	Mitigation measures were identified in the Renton EIS
Energy consumption	Depending on the alternative and the hauling distance, year 1990 fuel consumption for trucking would vary from 24,455 to 462,455 gallons.	Less fuel would be required for application sites close to the Metro treatment plants. When total energy consumption is considered, more energy would be produced by methane gas (heating, generation of electricity) than would be consumed.
Site impacts at West Point treatment plant	Minor construction impacts only with Alternative 2A (Taulman-Weiss tank composting)	Standard construction-related mitigation measures for dust suppression, traffic and noise
Sludge-haul truck traffic	Increases in sludge hauling traffic from the Renton treatment plant from no trucks/day in 1983 to 9/day by the year 2000; increases from 9 trucks/day in 1983 at West Point to 13/day by 1987, then a decrease to 9/day by 2000.	None required.

Table S-2. Impacts of Land Application of Sludge

Area of Impact	Description of Impact	Mitigation Measures
	Impacts of Agricultural Application	
Soils	Increase in organic content of soil; increases in heavy metal content of soil; annual loading of cadmium of 0.32 kg/ha (0.28 lb/ac); increases in nitrogen to soil of 98 lbs/ac/yr.	Lime soils to achieve a pH of 6.5 or greater; follow DOE BMPs for the Use of Sewage Sludge.
Land use	Cadmium loading at the estimates of 0.32 kg/ha/yr would not limit future land use of the site (even for growing food chain crops) so long as cumulative cadmium loading would not exceed 5-20 kg/ha (as determined by soil cation exchange capacity, CEC).	Cumulative cadmium loading must conform to EPA regulations (40 CFR 257) as determined by the CEC of the soil.
Vegetation and crops	Uptake of heavy metals by plants would occur in varying amounts.	Limitations to the crops grown should be based on 40 CFR 257 and DOE BMPs.
	Impacts of Composting	
Land use	Development of a composting facility would generally be compatible with industrial land uses; residential areas peripheral to the site could be adversely affected by composting activities.	Consideration should be given to designing the site to minimize light, glare and noise if sensitive receptors are in the vicinity.
Worker exposure to composted sludge	Continual exposure to sludge compost could cause aspergillosis or uptake of pathogens from aerosols.	Maintenance of high internal composting temperatures (130°F-150°F) would reduce pathogens; use of breathing masks and enclosed cabs on composting vehicles could reduce worker exposure; sprinkling site should be done to reduce dust.
Water quality	Runoff from composting site could cause impacts on surface water or groundwater.	Site should be designed with an impervious surface area and runoff collection system connected to a sewer.
Public health	Heavy use of composted sludge by homeowner for growing vegetable could cause a buildup of heavy metals in the soil.	Future regulations will dictate ultimate use of composted material; labeling for consumer protection could be provided on compost bag.
	Impacts of Silvicultural Application	
Geology and soils	Improvement in the texture of coarse soils and reduced susceptibility of soil to erosion; slight, temporary decrease in infiltration rate; changes in pH followed by slight increase; increase in organic matter; increase in essential plant nutrients; increase in heavy metals content.	Use of DOE BMPs to identify proper sites for sludge application.

Table S-2. Cont'd.

Area of Impact	Description of Impact	Mitigation Measures
Silviculture	Increase in growth response of Douglas-fir, Sitka spruce, poplar and cottonwood; possible damage to buds of young Douglas-fir seedlings.	Application of sludge well before bud-burst in the spring.
Surface and groundwater	Potential for nitrate and, depending on CEC of soil, heavy metal and pathogen movement into water; possible contamination of a drinking water supply.	Where possible,apply sludge on a site with an isolated aquifer and not used as a drinking water supply; to limit nitrate leaching apply sludge at a rate necessary to meet the nitrogen requirement of the forest. Follow DOE BMPs.
Terrestrial wildlife and aquatic life	See Table S-3.	See Table S-3.
	Impacts of Soil Improvement	
Soils	Increase in organic and nutrient content of mineral soils; improved soil stability and texture.	None needed.
Land use	Location of storage lagoons or application areas may adversely affect surrounding land uses; proposed use of sludge on gravel pits, surface mines, powerline rights-of-way and landfills may interfere with primary day-to-day use of sites.	Selection of sites remote from sensitive visual and odor receptors; careful selection of application sites and development of an operations plan for Metro and the site user.
Groundwater and surface water	Leaching of nitrates and heavy metals and movement of pathogens and organics may impact groundwater and surface water resources.	Where groundwater is now or may possibly be a drinking water source in the future, surface water monitoring stations should be established above and below area of sludge application; groundwater monitoring should be both up-gradient and down-gradient of a sludge-treated area (DOE 1982a).

Table S-3. Impacts of the Pilchuck Demonstration Project

Area of Impact	Description of Impact	Mitigation Measures
Soils	Compaction on roads and trails by application vehicle.	Sludge vehicle travel routes should be carefully selected. Design and maintenance of skid roads to reduce ponding of water.
	Temporary reduction in soil infiltration.	None needed.
	Improvement of soil structure.	None needed.
	Increase in soil nutrients.	None needed.
	Fluctuations in soils pH.	None needed.
	Increase in heavy metals content of top 4-6 inches of soil.	Limiting sludge loading per acre to allow for even the most restrictive (agriculture) future land use.
	Possible direct spraying of sludge into creeks.	Place road network no closer than 150 feet from cliff edge. High visibility markers should be located at edge of buffer zone.
Surface water	Possible accidental spills into creek.	Check structural integrity of Kunze Creek bridge.
	Runoff off site into surface water.	Cease sludge application if ground should freeze.
Groundwater	Nitrate leaching to groundwater.	Groundwater movement away from drinking water source. Groundwater monitoring program as proposed by Metro.
	Possible impact from rainwater spray site.	Establish best location for site based on groundwater information. Establish monitoring well down-slope of spray application site.
Wildlife	Direct sludge ingestion, bioaccumulation, and possible chronic toxicity to wildlife.	None.
Silviculture	Increases in growth response to trees and understory vegetation.	None required.
	Potential minor changes in wood quality.	
Aquatic ecosystems	Small likelihood of adverse effect on fish populations.	Utilize measures previously described for Surface Water.
Transportation	Increase in opportunity for traffic accidents on Armstrong Road.	Improvement to Armstrong Road advance warning signaling device to ensure that it functions properly. Road sign installation warning motorists of wide load vehicles using Armstrong Road.
	Increase in deterioration of Armstrong Road.	Metro coordinate with Snohomish County to establish cooperative maintenance checks and repairs.

Table S-3. Cont'd.

Area of Impact	Description of Impact	Mitigation Measures
Aesthetics	Sludge-blackened trees, occasional odors and noise.	Site isolation would reduce many of impacts. Sludge spraying closest to residences limited to calm days or when winds are from the north or northeast. Possible increase in width of the northern buffer zone. Changes in truck hauling or operation schedules if problems with proposed schedule arise.
Recreation	Area closed to recreational uses for 13 to 20 months.	Greater use of remaining Pilchuck Tree Farm lands for recreation; adequate posting to warn recreationists away from site.
Cultural resources	Small likelihood of encountering cultural resources during construction activities.	Notify archeologist if cultural resources encountered.
Public health	Potential impact on groundwater and surface water.	Groundwater trending away from drinking water supply. Initiation of monitoring program as defined by Metro.
	Aerosol drift.	Limit sludge spraying closest to residential areas to calm days or days when prevailing wind is away from residential areas.
	Effect of sludge on edible mushrooms and berries.	Utilize results of studies to determine if site should be closed to picking berries and mushrooms.

Table S-4. List of Possible Permits and Approval Required by Metro

STATE AND LOCAL	PERMITS AND APPROVAL
Department of Ecology	State Environmental Policy Act
	201 Facilities Plan Approval Section 201-PL92-500/Clean Water Act
	Shoreline Management Permit
	State Waste Discharge Permit NPDES Permit
Office of Archeology and Historic Preservation	Project Approval
Departments of Fisheries and Game	Hydraulic Permit (already issued)
Snohomish Health District, Environmental Health Division	Land Application of Sludge Permit

Public Involvement

Public participation for this EIS has been coordinated and, where possible, integrated with the full-scale public participation program undertaken by Metro in preparing its Draft Sludge Management Program. Key EIS public participation activities have included publication and distribution of an EIS information brochure, conducting scoping meetings, and an EIS presentation to the Citizen's Advisory Committees.

This Draft EIS has been forwarded to numerous federal, state and local agencies, special interest groups, private citizens, and public libraries to act as both an informational document and as an avenue to comment on the proposed wastewater project. (The Draft EIS mailing list is presented in Appendix H).

Individuals or groups that wish to comment on the EIS may forward written comments to:

U. S. Environmental Protection Agency
Region 10
1200 Sixth Avenue
Seattle, Washington 98101
Attention: Kathryn Davidson

Comments should be sent by: May 30, 1983.

Joint public hearings have been scheduled on the Draft Sludge Management Plan and Draft EIS by Metro and EPA.

During these public hearings, formal oral and written testimony will be received.

Chapter 1

Introduction

- Environmental Impact Statement Requirement
- Metro's Sludge Management Plan
- EIS Context
- Public Participation
- Legal, Policy, and Institutional Considerations

Chapter 1

INTRODUCTION

Environmental Impact Statement Requirement

The Municipality of Metropolitan Seattle (Metro) has prepared a Draft Sludge Management Plan for managing sewage sludge produced at the Metro wastewater treatment facilities. This Draft Environmental Impact Statement (EIS) has been prepared by the Environmental Protection Agency (EPA), Region 10, to assess the Sludge Management Plan's environmental consequences.

The relevant EPA decisions are to approve the Sludge Management Plan, the preparation of which is partially federally funded, and to partially fund projects called for in the plan. This EIS satisfies EPA's environmental review responsibilities under the National Environmental Policy Act (NEPA), and will be used to satisfy Metro's environmental review responsibilities under the Washington State Environmental Policy Act (SEPA).

Organization of the EIS

This Draft EIS consists of a main text and accompanying technical appendices. This chapter, Chapter 1, discusses the purpose and need for Metro's Sludge Management Plan; describes the organization and context of the EIS; summarizes EIS public participation activities; and defines relevant legal, policy and institutional considerations.

Chapter 2 of the EIS provides an overview of sludge management concepts, a description of Metro's existing sludge management methods, sludge quantity and quality, a description of alternatives considered by Metro, an overview of composting, silvicultural application, agricultural application and soil improvement, and a description of Metro's preferred plan.

Chapter 3 describes the environmental setting and assesses the impacts of Metro's sludge management alternatives for the 20-year preferred plan and for the Pilchuck sludge application demonstration project.

Chapter 4 identifies EIS coordination activities and is followed by a list of EIS preparers and the bibliography.

Seven technical appendices have been prepared which present detailed information on public health (Appendix A), properties of forest soils (Appendix B), silviculture (Appendix C), endangered and threatened species (Appendix D), cultural resources (Appendix E), water quality and groundwater data (Appendix F), and the distribution list (Appendix G).

Metro's Sludge Management Plan

Purpose and Need

Metro has prepared its Sludge Management Plan for the following reasons:

1. Prior recent Metro wastewater facilities plans, including the 1980 Wastewater Management Plan for the Lake Washington/Green River Basins (covering Metro's Renton Treatment Plant), did not include a comprehensive evaluation of sludge management and disposal.

2. A plan for sludge use is important to ensure proper treatment system design at the Renton Treatment Plant.

3. A sludge management plan is a required component of the National Pollutant Discharge Elimination System (NPDES) permits issued by DOE.

4. Future capacities to recycle or dispose of projected year 2000 sludge quantities should be assured.

5. Through the planning effort, Metro needs to identify cost-effective sludge management alternatives.

Development of the Sludge Management Plan

Metro's current sludge management planning has been influenced by a number of previous actions and planning efforts. In 1965, a decision was made to transport sludge by force main from the Renton Treatment Plant to the West Point Treatment Plant for treatment and disposal. Because of that decision, all sludge handling and disposal from 1966 to the present has been through the West Point plant. In Metro's Wastewater Management Plan for the Lake Washington/Green River Basins (1980), recommendations were made to provide solids handling facilities for sludge digestion and dewatering at the Renton Treatment Plant. Construction of those facilities is scheduled to begin in mid-1984.

The process for preparing the current Draft Sludge Management Plan is described in detail in Metro's draft plan, and will therefore only be summarized here. The following is a chronological order of reports and events leading to the draft plan:

1. December 1980: Preliminary Draft cost-effectiveness analysis of system-wide sludge management alternatives.

2. June 1981 - May 1982: Technical memoranda on site selection criteria, soil improvement, silviculture, and urban distribution.

3. July 1981: Creation of Citizens Advisory Committee.

4. August 1982: Preliminary Draft Sludge Management Plan.

5. September 1982: Preliminary Draft report, Pilchuck Tree Farm demonstration sludge application project.

6. November 1982: Revised Preliminary Draft Sludge Management Plan.

7. December 1982: Revised sludge disposal and reuse cost-effectiveness evaluation.

8. January 1983: Draft Risk Analysis, Pilchuck Tree Farm demonstration sludge application project.

In March 1983, Metro will issue its Draft Sludge Management Plan for public review and comment. That plan will include discussions of sludge management issues, sludge characteristics, alternatives considered, recommended long-range and near-term plans, and public participation.

Metro's plan covers a 15-year planning period, while the near-term plan covers 5-year and 1-year planning periods. The sludge management plan includes long-range sludge management goals focusing on soil improvement, agricultural application, silvicultural application and production, and marketing of a composted sludge product, the 5-year plan covers the following subject areas: planning objectives, quantities and characteristics of sludge, project identification methods, project evaluation procedures, and project implementation. The 1-year plan identifies specific projects for which approval will be sought by Metro during the next year.

EIS Context

Major Issues Addressed by EIS

Preparation of the Sludge Management Plan has raised a number of important issues. Based on public input during the scoping process and consultation with affected agencies, the following issues have been determined to be of greatest importance to this EIS:

1. Completeness in the range of alternatives considered.

2. Relationship of the sludge management plan to Metro's near-term sludge disposal activities.

3. Cost of sludge disposal alternatives.

4. Local jurisdictional authority over sludge disposal outside Metro's service area.

5. Impact of federal and state regulations.

6. Ability to demonstrate the benefits of sludge reuse.

7. Impact of sludge transportation on traffic congestion and circulation.

8. Risk of accidental spills during sludge transportation and disposal.

9. Impact of sludge disposal on surface water and groundwater.

10. Public access and recreation at disposal sites.

11. Effect of future land use changes or land use restrictions on sludge disposal sites.

12. Effect of sludge disposal on public health.

13. Effect of sludge disposal on fish and wildlife resources.

14. Aesthetic impacts of sludge disposal including odor and noise.

15. Monitoring and mitigation measures for sludge disposal sites.

16. Effect of sludge application on timber management practices.

17. Effect of sludge application on insects and other invertebrates.

18. Effect of sludge application on mushrooms and other edible wild foods.

The EIS emphasizes the above issues, but also covers the entire range of biophysical and socioeconomic impacts related to Metro's near-term and long-range alternatives.

Public Participation

The public participation program for this EIS has been coordinated and, where possible, integrated with Metro's extensive public participation program for its Sludge Management Plan.

The EIS process for Metro's Sludge Management Plan was initiated in July 1981. On November 6, 1981, EPA published in the Federal Register its Notice of Intent to prepare the EIS. On December 9, 10, 15, and 16, 1981, public EIS "scoping" meetings were held in conjunction with Metro public information meetings in Orting, Arlington, Seattle, and Belfair, Washington. A responsiveness summary of public comments and responses to questions received at the "scoping" meetings was prepared and distributed in April 1982.

Joint Metro and EPA public information meetings are scheduled to be held May 3 and 5, 1983 in Seattle and Arlington, Washington. The purpose of those meetings will be to present the proposed project and impact analysis to the public and to answer any questions the public might have.

Public hearings on the Draft EIS and Draft Sludge Management Plan are currently scheduled for May 15 and 17, 1983. Based on public input, the Draft EIS and draft plan will be revised, and final versions of the documents will be released in the fall of 1983. A Metro decision on the final plan will then be made. Subsequently, EPA and DOE will take approval actions on the final plan. A facilities design grant will be made according to state funding priorities.

The Draft EIS comment period, the public hearings to be held on the Draft EIS, responses to comments to be included in the Final EIS, the comment period for the Final EIS and the response to comments in the Record of Decision will fulfill EPA's remaining formal public participation responsibilities under NEPA.

Legal, Policy, and Institutional Considerations

EPA is required to integrate EIS preparation with the requirements of other environmental laws and executive orders (40 CFR S1502.25; 40 CFR S6.300); to identify in EISs federal permits, licenses and entitlements which must be obtained to implement an action (40 CFR 1502.25); and to identify in EISs inconsistencies of an action with state and local plans and laws (40 CFR S1506.2). The purpose of this section is to review federal, state and local environmental requirements which are relevant to either alternatives considered in Metro's Sludge Management Plan or to this EIS.

Of the various environmental requirements, some will be complied with as part of preparation of Metro's Sludge Management Plan or this EIS. Others can only be complied with when Metro proposes specific future projects pursuant to the Sludge Management Plan.

Federal Requirements Relevant to Sludge Management and Disposal

Clean Water Act (42 USC S1857 et seq.). The goals of the Act are to achieve "fishable, swimmable" surface waters throughout the nation by 1983, and to achieve no discharge of pollutants by 1985. Section 201 of the Clean Water Act establishes a construction grants program for municipal wastewater facilities, wherein federal grants are offered for the planning, design, and construction of publicly-owned treatment works. This funding is 75 percent (85 percent for innovative and alternative technology projects) of the eligible costs of municipal wastewater treatment plants and sludge management facilities. Metro's Sludge Management Plan has been funded with a Step 1 construction grant.

Section 208 of the Act establishes an areawide waste treatment management planning process; Section 208 plans must develop controls for both point and nonpoint sources of water pollution. Under Section 303 of the Act, states are required to prepare and enforce ambient water quality standards and to prepare basin plans showing how these standards will be met. Metro's Sludge Management Plan must be consistent with areawide and state water quality management plans.

Under Sections 401 and 402 of the Act, EPA or the states are required to issue NPDES permits for all point sources of pollution. NPDES permits for wastewater treatment plants include sludge disposal conditions where possible, thus reducing the need for separate sludge disposal permits.

Several portions of the Act relate specifically to sewage sludge management. Section 405(d) requires EPA to promulgate guidelines and regulations for sewage sludge disposal. Pursuant to both this section and requirements of the Resource Conservation and Recovery Act (RCRA), EPA has issued Criteria for the Classification of Solid Waste Disposal Facilities and Practices (Criteria) (40 CFR Part 257). The Criteria set forth specific requirements for protection of floodplains, endangered species, surface water, groundwater, sludge application to land used for production of food-chain crops, disease vectors, air emissions, and safety. They regulate all land-based alternatives for sewage sludge disposal, including landfilling, nonagricultural land application, and agricultural land application. Sludge management projects implemented pursuant to Metro's Sludge Management Plan must be consistent with the Criteria.

Under authority of Section 405(d), EPA is also currently developing regulations (40 CFR Part 258) for the public distribution and marketing of sewage sludge-derived fertilizer products. Other portions of the Act related to sludge management include Section 307, which encourages the utilization of sludge by requiring pretreatment of industrial wastes entering publicly-owned treatment works. Metro has implemented a pretreatment program pursuant to the Act.

The Resource Conservation and Recovery Act (42 CFR 3251 et seq.). RCRA establishes national policies and programs for solid waste management, in general, and for hazardous waste management, in particular. With respect to solid waste management, the Act prohibits new open dumping sites, requires that all open dumping sites be converted to sanitary landfills or closed by 1983, and authorizes the preparation of the Criteria previously reviewed. The Act further provides financial assistance for the development and implementation of comprehensive state solid waste management plans, which are to include environmentally-sound disposal methods and resource recovery programs.

Subtitle C of RCRA establishes a program for comprehensive "cradle-to-grave" regulation of hazardous wastes. RCRA hazardous waste regulations do not apply because Metro's sludge is not classified as a hazardous waste, based on testing for contaminant levels.

The Clean Air Act (42 USC 1857 et seq.). The Clean Air Act (CAA) sets the basic framework for federal, state, and local air quality management programs. The major implementation provision of the CAA requires each state to establish and implement a plan to achieve federal ambient air quality standards within specified time frames. The resulting State Implementation Plans (SIPs) provide the regulatory programs for controlling pollutant emissions from existing and future sources. EPA procedures require the agency to consult with appropriate state and local agencies when a proposed action may have a significant effect on air quality to determine the conformity of the action with the applicable SIP (40 CFR S6.303).

The Act provides for two sets of national ambient air quality standards, primary standards (for the protection of human health) and secondary standards (for the protection of other values such as crops and materials). The Act also provides for national emissions standards for hazardous pollutants, and for new source performance standards for certain industrial categories.

Areas which exceed any federal primary air quality standard (nonattainment areas) are required by the Act to control both existing and new emission sources so as to achieve annual incremental reductions in pollutant emissions until the federal standards are met. The Act requires states to establish new source review programs for major new stationary sources and to establish a program for prevention of significant deterioration in areas that currently meet national ambient standards.

Incineration and thermal reduction of sludge must meet a number of CAA requirements. Most importantly, these alternatives must comply with SIP emission limitations, with national emissions standards for hazardous pollutants, and with new source performance standards.

Marine Protection, Research and Sanctuaries Act (33 USC 1401 et seq.). Under this law, ocean dumping of sewage sludge after December 31, 1981 is prohibited. The Metro Sludge Management Plan is consistent with the Act because ocean dumping of sewage sludge is not proposed.

Safe Drinking Water Act (42 USC 300f et seq.). This law establishes the national program for protecting drinking water supplied by municipal and industrial water suppliers. Pursuant to the Act, EPA has issued national primary drinking water standards to protect human health (40 CFR Part 143). These standards are minimums to be adopted by the states and applied to municipal and industrial water suppliers. Under the Act, states with approved programs have the primary implementation and enforcement authority.

Section 1424(e) of the Act authorizes EPA to determine that an underground aquifer is the "sole source" of drinking water for an area or community. Once an aquifer is so designated, no federal financial assistance is available for projects which may contaminate the aquifer. Sole source aquifers in the State of Washington include the Rathdrum Prairie Aquifer east of Spokane, and the Whidbey and Camano Islands aquifers.

Section 1442 of the Act requires states to conduct a "Surface Impoundment Assessment" to locate all surface impoundments (pits, ponds, and lagoons) and assess them for pollution potential. The Washington DOE has completed this assessment.

Lastly, Section 1421 of the Act authorizes state underground injection control programs. The state program would apply if sludge is injected into the ground or abandoned wells or mines.

Surface Mining Control and Reclamation Act of 1977 (30 CFR 700 et seq.). SMCRA sets forth the requirements and general performance standards for surface mining activities throughout the United States. Under the Act, mine owners are obligated to restore surface mine sites to conditions suitable to support vegetation and postmining land uses. The Act specifies that nutrients and soil amendments should be applied to the surface soil layer so as to support postmining land uses and requirements of revegetation.

The Toxic Substances Control Act (15 USC 2601 et seq.). The Toxic Substances Control Act (TSCA) empowers EPA to control production and use of toxic substances. Under the Act, EPA is empowered to regulate any aspect of chemical use likely to result in an unreasonable risk of serious or widespread injury to public health or the environment. The Act prohibits the production of polychlorinated biphenyls (PCBs) after January 1979 and the distribution of PCBs in commerce after July 1979, resulting in an expected long-term decline in the PCB content of municipal sludge.

The Act also requires coordination with the CAA and Clean Water Act to restrict disposal of hazardous wastes. High concentrations of PCBs in sewage sludge would cause it to be considered a hazardous waste regulated by TSCA.

Federal Requirements Relevant to EIS

This section describes a number of federal environmental laws and policies relevant to EIS preparation. Because it is not presently known which specific Metro sludge management projects EPA may be funding, compliance with many of the requirements cannot yet be demonstrated. EPA will comply with such project-specific requirements when and if specific sludge management projects are proposed for federal funding.

National Environmental Policy Act (42 USC 4321 et seq.). NEPA and regulations issued pursuant to NEPA establish policies and procedures for assuring that federal actions are consistent with the nation's environmental quality objectives. NEPA directs that, to the fullest extent possible, federal agencies are to carry out their programs in accordance with NEPA policies and procedures. NEPA's "action-forcing mechanism" requires that federal agencies prepare EISs, using a "systematic, interdisciplinary approach" to assess the impacts of "major federal actions significantly affecting the quality of the human environment."

Regulations of the Council on Environmental Quality (CEQ) (40 CFR Sections 1500-1508) and EPA (40 CFR Part 6) provide detailed requirements for implementing NEPA. Preparation of this EIS satisfies EPA's environmental impact review responsibilities under NEPA.

A-95 Review. The Intergovernmental Cooperation Act (ICA) of 1968 (42 USC 4233) and Office of Management and Budget (OMB) Circular No. A-95 (42 FR 4052, January 13, 1976) require coordination of federal aid programs with state, areawide, and local comprehensive planning. The ICA establishes a national policy for intergovernmental coordination and cooperation, and requires consistency to the maximum extent practicable between federal aid for development purposes and state, regional, and local planning.

OMB Circular A-95 establishes a system for notification and review of state and local applications for federal assistance and for consultation regarding direct federal development projects. This A-95 review system also provides a mechanism for dissemination of EISs, environmental assessments, and other analyses prepared by federal agencies to interested state and local government agencies for comments, as required by NEPA.

Various state and areawide clearinghouses facilitate the notification, review and dissemination of project plans and EISs, as specified by OMB Circular A-95.

This EIS will be disseminated through the A-95 review system. If specific Metro sludge management projects are proposed for federal funding, Metro grant applications will also be disseminated through the A-95 review system.

Endangered Species Act (16 USC 1536 et seq.). Federal policies and procedures for protecting endangered and threatened species of fish, wildlife, and plants are established by the Endangered Species Act (ESA) and regulations issued pursuant to the Act. The purposes of the Act are to provide mechanisms for conservation of endangered and threatened species and the habitats upon which they depend, and to achieve the goals of international treaties and conventions related to endangered species. Under the Act, the Secretary of the Interior is required to determine which species are endangered or threatened, and to issue regulations for protection of those species.

Section 7 of the Act requires federal agencies to consult with the U. S. Fish and Wildlife Service (USFWS) in order to ensure that actions they authorize, fund, or carry out are not likely to jeopardize the continued existence of a listed species or result in the adverse modification or destruction of their critical habitat. Upon determination that an endangered or threatened species may be present in the area of a proposed action, the responsible agency must conduct a biological assessment to identify how the listed species might be affected. The biological assessment may be performed as part of an environmental assessment or EIS pursuant to NEPA. EPA will undertake Section 7 consultation when a determination is made as to which specific Metro sludge management projects EPA may be funding.

The Coastal Zone Management Act (16 USC 1451 et seq.). The Coastal Zone Management Act (CZMA) offers grants to coastal states for the development of comprehensive, long range coastal management plans meeting broad statutory criteria, and for state implementation of these plans following federal approval. The Act is administered by the National Oceanic and Atmospheric Administration (NOAA). In Washington, the approved coastal management plan consists of the state's Shoreline Management Act and local Shoreline Master Programs.

The CZMA (Section 307[d]) requires that federal agencies disapprove funding assistance for local projects that are inconsistent with a state coastal zone management program. State coastal management agencies are required to make the consistency determination as part of the A-95 review of the application for federal assistance (15 CFR 930, subpart F). If specific Metro sludge management projects affecting the coastal zone are proposed for federal funding, consistency determinations for these projects will be made.

Cultural Resource Protection. A number of federal laws and regulations have been promulgated to protect the nation's historical, cultural, and prehistoric resources. These include the National Historic Preservation Act, the Archeological and Historic Preservation Act, the Archeological Resources Protection Act, and the American Indian Religious Freedom Act.

Pursuant to the National Preservation Act (NPA) (16 USC 470 et seq.), the effects of any federal or federally-assisted undertaking on historical, cultural, or archeological resources must be evaluated. An "effect" is defined as any change in the quality of the characteristics that qualify the resource for protection under the law (36 CFR 800). For properties on or eligible for the National Register of Historic Places, the responsible federal agency must consult with the State Historic Preservation Officer (SHPO) regarding any potential adverse effects on resources of historic, architectural, archeological, or cultural significance.

The Archeological and Historic Preservation Act (88 Stat. 174) and the Archeological Resources Protection Act (93 Stat. 721) safeguard historical and archeological resources from damage or loss to federally-sponsored or permitted projects, and from excavation or removal from federal and Indian lands, respectively. The American Indian Religious Freedom Act (42 USC 1776) assures that federal activities do not impair access to religious sites and will not affect ceremonial rites of American Indians.

Cultural resource protection laws will be complied with if specific Metro sludge management projects are proposed by federal funding at sites where the resources could be affected.

Recreational and Wilderness Area Protection. A number of federal programs have been created to protect important national recreation and wilderness resources. These include the National Wild and Scenic Rivers System, established by the Wild and Scenic Rivers Act (16 USC 1271 et seq.); the National Trails System, established by the National Trails System Act (16 USC 1241 et seq.); wilderness areas administered by the U. S. Forest Service, Bureau of Land Management (BLM), and the National Park Service; Areas of Critical Environmental Concern administered by BLM; and estuarine sanctuaries designated pursuant to the CZMA. In general, these programs include provisions to discourage federal agencies from taking actions which would impair the recognized values of the resources in question. Recreational and wilderness area protection laws will be complied with if specific Metro sludge management projects are proposed for federal funding at sites where these resources could be affected.

Protection of Agricultural Lands. On September 8, 1978, EPA issued its policy to protect environmentally significant agricultural lands. Under this policy, EPA is required to identify the direct and indirect impacts of its actions on environmentally significant agricultural lands and to avoid or mitigate, to the extent possible, identified adverse impacts.

The Council on Environmental Quality issued a memorandum in 1980 emphasizing the need for determining the effects of proposed federal agency actions on prime or unique agricultural lands (45 FR 59189, September 8, 1980). Prime farmlands are to be considered a "depletable resource" and impacts to them must be evaluated in the environmental assessment process. Impacts to be evaluated include reduction in farmland productivity and conversion of farmlands to other uses.

These policies will be complied with if specific Metro sludge management projects affecting agricultural lands are proposed for federal funding.

Floodplains and Wetlands. Executive Order 11988 requires federal agencies, in carrying out their responsibilities, to take action to reduce the risk of flood loss; to minimize flood impacts on human safety, health, and welfare; and to restore and preserve the natural and beneficial values served by floodplains. Executive Order 11990 requires federal agencies, in carrying out their responsibilities, to take action to minimize the loss or degradation of wetlands, and to preserve and enhance the natural and beneficial values of wetlands. Each agency is required to avoid undertaking or providing assistance for construction in wetlands unless the agency finds there is no practicable alternative and the proposed action includes all practicable measures to minimize harm to wetlands.

EPA has developed procedures implementing these Executive Orders on floodplain management and wetlands protection (40 CFR 6, Appendix A). Under these procedures, EPA is required to assess floodplains and wetlands impacts of its actions, and to either avoid adverse impacts or minimize them if no practicable alternative to the action exists.

These policies will be complied with if specific Metro sludge management projects affecting floodplains and wetlands are proposed for federal funding.

State Requirements

Solid Waste Management and Recycling (RCW 70.95). This law establishes a statewide program for solid waste management. Sewage sludge is considered a solid waste, and therefore sludge management and disposal must comply with provisions of the law and its associated regulations, the Minimum Functional Standards for Solid Waste Handling (WAC 173-301). Under this law, each county board of health is required to adopt regulations governing solid waste handling and develop a permit system for solid waste disposal sites or facilities. The county regulations may be more stringent than the state's minimum functional standards. The law also requires preparation of local solid waste management plans, which must address sludge utilization.

The state has prepared draft Municipal Sludge Utilization Guidelines (Guidelines) and draft Best Management Practices (BMPs) for Use of Municipal Sewage Sludge, as a supplement to the state minimum functional standards. The Guidelines establish general criteria for the storage, transportation, and use of municipal sludge; they also require a site design and operation plan for sludge utilization sites to be approved by the jurisdictional health department. The BMPs provide technical information and recommend specific utilization practices complying with the state Guidelines and federal criteria.

Washington Clean Air Act (Chapter 70.94 RWC). This act defines public air quality policy, delineates air pollution control authorities and responsibilities and sets forth the framework for emission control schedules, variances, penalties, burning permits, air pollution episodes, and outdoor burning.

State Clean Water Act (CWA) (RCW 90.48). This Act establishes wastewater discharge standards in compliance with the Federal Clean Water Act; these standards dictate the necessary degree of treatment which in turn influences the quantity and quality of sludge. Also, a proper sludge disposal plan is reviewed under the NPDES permit process. For a given sludge utilization site, the Act is only relevant when processing facilities such as digesters, dewatering equipment, drying beds, and incinerators are involved; when there is a direct discharge of pollutants to surface water; or when sludge is applied to land in quantities above those required for crops (Guidelines, Section 1.07).

Washington State Environmental Policy Act (RCW 43.21C). This Act and its implementing guidelines (WAC 197-10) require that environmental factors be included in state agency, municipal and public corporation, and county decision-making processes. The Act requires state EISs to be prepared for actions significantly affecting the quality of the environment. Under the SEPA guidelines (WAC 197-10-650), adequate EISs prepared under NEPA may be utilized by state and local agencies in lieu of a separately prepared EIS under SEPA; Metro intends to use this EIS to satisfy SEPA requirements.

Shoreline Management Act (RCW 90.58.200). This Act, together with local Shoreline Management Programs prepared pursuant to state guidelines (WAC 173-16), comprise Washington's coastal zone management program. Local Shoreline Management Programs cover shorelines of marine waters, lakes over 20 acres, and streams with flows greater than 20 cfs. Each Shoreline Management Program must reflect state policies for four types of environments (natural, conservancy, rural, and urban), state-designated shorelines of statewide significance, a number of natural systems, and a number of use activities (which include forest management practices and solid waste disposal). Metro's sludge disposal siting must conform with local Shoreline Management Program requirements.

Forest Practices Act (RCW 76.09). This Act and the associated Forest Practices Regulations (WAC 222-08 et seq.) establish minimum standards for forest practices in Washington. Silvicultural application of wastewater sludge will need to comply with relevant forest practices standards and administrative procedures.

Local Requirements

Specific sludge management projects implemented pursuant to Metro's Sludge Management Plan must comply with a variety of local requirements, including jurisdictional health department regulations, local solid waste management plans, and local land use and Shoreline Management Plans and policies. Jurisdictional health departments are required by state law to issue permits for sludge utilization projects on land, and local agencies may also require grading permits, special use permits, or shoreline permits, depending on the local jurisdiction. Jurisdictional health department levels of review and forms of approval for a given sludge utilization project are at the discretion of the health department (Guidelines, Section 1.04).

Snohomish County's requirements are particularly relevant to Metro's Sludge Management Plan because the Pilchuck Tree Farm Demonstration Project, proposed as part of Metro's plan, is located in Snohomish County. The Snohomish Health District requires a permit for land application of wastewater sludges. Criteria for approval are based on compliance with the state Guidelines and federal regulations.

Chapter 2

Description of Sludge Management Alternatives

- Overview
- Metro's Existing Sludge Management Concepts
- Existing Sludge Management Methods
- Description of Alternatives Considered
- Metro's Preferred Long-Range Sludge Management Program
- Metro's Preferred Near-Term Plan

Chapter 2

DESCRIPTION OF SLUDGE MANAGEMENT ALTERNATIVES

This chapter presents an overview of sludge management methods, describes Metro's existing sludge management methods and existing sludge characteristics, and describes future sludge management alternatives considered and recommended by Metro.

Overview of Sludge Management Concepts

Sludge Management Principles

Sewage sludge is the semi-solid material formed during the wastewater treatment process. It consists of organic and inorganic solids removed during primary treatment and organic solids removed during secondary treatment. Sewage sludge typically undergoes treatment prior to disposal or reuse to achieve volume reduction and disinfection. Following treatment, it is transported to a disposal or reuse site.

The sludge treatment process is designed to transform raw sludge into a more manageable form. Depending on the final usage, sludge may be thickened, digested, conditioned, dewatered, composted, dried, disinfected, and/or incinerated. Thickening increases the solids concentration, reducing the volume. Digestion stabilizes the sludge, reduces its volatile solids content, and provides some disinfection. Also, energy in the form of methane gas can be recovered using the anaerobic method of digestion. Conditioning serves to improve the sludge dewatering and may be a chemical or physical technique. Dewatering increases sludge solids content and reduces volume, by removing a significant portion of the water contained in sludge and some dissolved constituents such as ammonia-nitrogen and potassium. Composting oxidizes part of the organic matter in sludge and can result in a drier, less odorous, and more disinfected product. Sludge disinfection removes pathogens and prevents the spread of diseases. Drying further reduces sludge moisture content and volume. Incineration greatly reduces sludge mass and volume and results in a sterile ash for disposal (EPA 1979a).

After treatment, sludge must be transported from the treatment plant to a disposal or reuse site. Transportation also may be required between the raw sludge collection point and the sludge treatment site. Common modes of transport are via truck, pipeline, barge, and train.

The final disposition of sewage sludge can include disposal or some beneficial usage. Landfilling (a disposal method) has been commonly used in the United States. Marine disposal has been essentially eliminated as a disposal system by action of the Marine Protection, Research and Sanctuaries Act. Soil reclamation, urban marketing, agricultural land application (food chain crops), and forestland application (nonfood chain crops), are examples of beneficial reuse of sludge.

Sludge Management Approaches of United States Cities

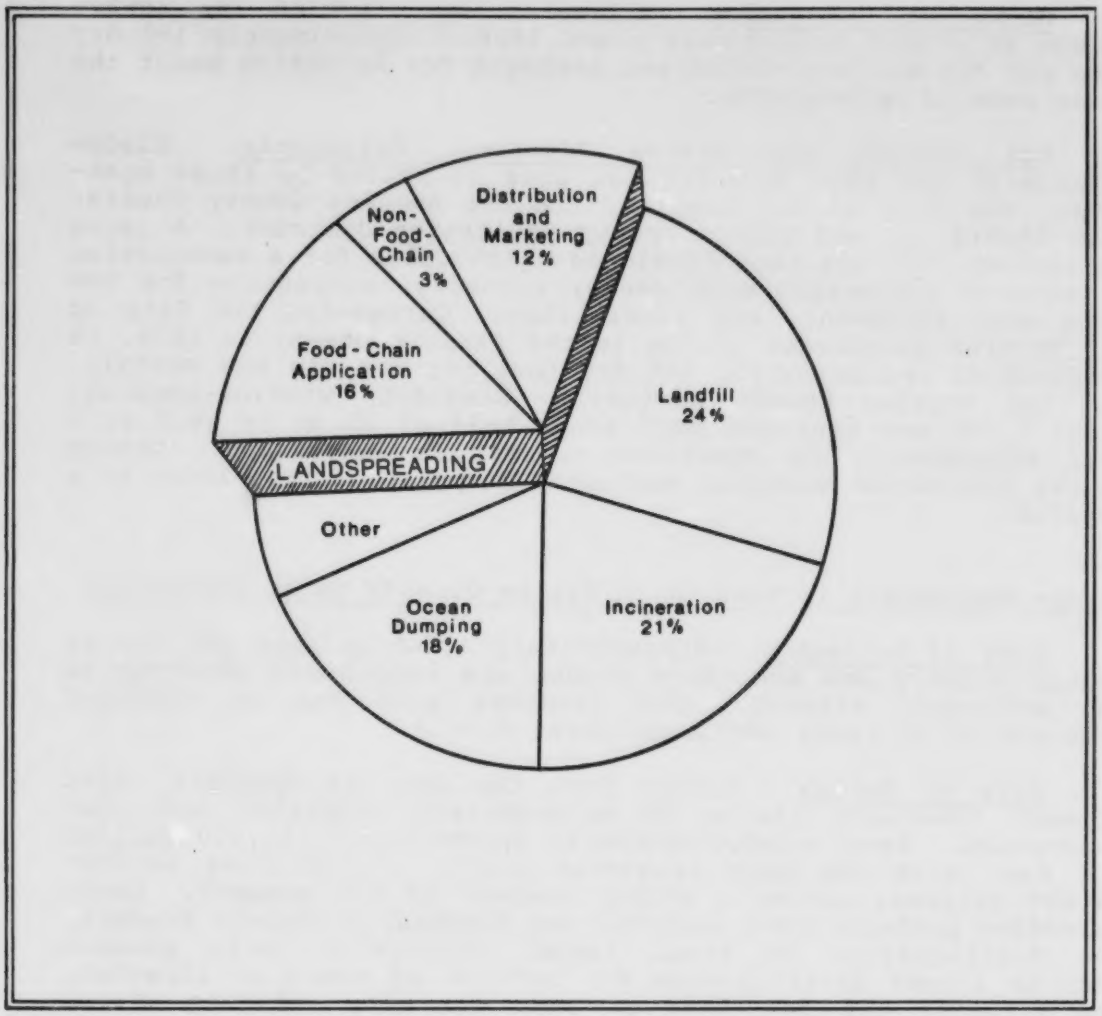
The main methods for sludge disposal throughout the United States in 1982 were:

- Incineration
- Landfill disposal
- Land spreading (food chain or nonfood chain)
- Distribution and marketing as fertilizer and soil amendment
- Ocean dumping (which is being phased out)

A survey of 350 large publicly-owned treatment works (accounting for about 40 percent of the sludge produced in the United States) provided the disposal distribution shown in Figure 2-1 (Peter *in* Bledsoe 1981). With phasing out of ocean dumping, those percentages will change as alternative methods are employed. Some examples of sludge management programs used by cities throughout the United States are discussed below.

Chicago, Illinois. During the past 10 years, the Chicago Metropolitan Sanitary District sludge management program has consisted of reusing heat-dried, air-dried and liquid sludge to reclaim approximately 40,000 acres of strip-mined land, as a soil amendment for citrus farms in Florida, as compost, and as a top dressing for landfill sites. The District produces 450 dry tons of sludge per day, and presently almost all is used as a top dressing for the City of Chicago landfill or for horticultural application (Gschwin pers. comm.). Future plans include using sludge for growing nursery stock on a City-owned site north of Chicago. The soil reclamation program and citrus farm programs have been phased out for economic reasons, and the composting (NuEarth soil supplement) program has been phased out because of concerns related to heavy metals concentrations in the sludge (Gschwin pers. comm.).

Denver, Colorado. Denver uses a land application method as its primary means of disposal; landfilling is used as a backup during cold weather (EPA 1979a). Land application, employed since 1969, consists of sludge application to the land, plowing, and sowing with a forage crop 2 months following application. Cattle then graze the area (Kienholz *in* Energy Research and Development Administration 1976). During cold weather this process cannot occur and a landfilling procedure is implemented. Sewage sludge is mixed with about 5 or 6 parts of soil and then layered on top of low areas in a landfill.



THIS DIAGRAM IS COMPILED FROM DATA FROM ABOUT 350 LARGER PUBLICLY OWNED TREATMENT WORKS (POTWs) ACROSS THE UNITED STATES.

SOURCE: PETER IN BLEDSOE, 1981

FIGURE 2-1

The Distribution of Sludge According to the Method of Disposal

Milwaukee, Wisconsin. Milwaukee has recycled its sewage sludge as a soil conditioner since 1926. Approximately 190 dry tons per day are heat-dried and packaged for marketing under the trade name of Milorganite.

Los Angeles and Orange Counties, California. Sludge management for this metropolitan area is shared by three agencies: the City of Los Angeles, the Los Angeles County Sanitation Districts, and Orange County Sanitation District. A joint management plan has been developed which calls for a combination of thermal processing with energy recovery, composting for use as a soil amendment, and landfilling. Currently, the City of Los Angeles discharges sludge to the Pacific Ocean; in 1978, it disposed of approximately 164 dry tons per day via the outfall. The Los Angeles County Sanitation Districts windrow-composts about 1,000 wet tons per day, about half of which is used as a soil amendment. The remaining compost is landfilled. Orange County Sanitation District currently disposes of its sludge at a landfill.

Sludge Management in Washington Cities Outside Metro Boundaries

City of Arlington. Approximately 1,500 gallons per day of liquid primary and secondary sludge are landspread adjacent to the Arlington airport. The 700-acre site has an expected lifespan of 15 years (Schlagel pers. comm.).

City of Tacoma. Sludge from the City of Tacoma's three primary treatment plants is anaerobically digested and then landspread. Total sludge volume is approximately 85,000 gallons per day, with the main treatment plant, contributing 45,000-50,000 gallons, having a solids content of 5-6 percent. Landspreading projects have included sod farming, a topsoil product, and fertilization on local lands. Future projects planned include forest fertilization for harvest of trees as firewood, and digester gas recycling as fuel for city vehicles (Price pers. comm.).

City of Edmonds. The sludge from Edmonds' primary treatment facility plant, which serves a population about 45,500, is incinerated and the ash landfilled. The incineration produces about 25-30 cubic yards of ash per year (Kopan pers. comm.).

City of Olympia. Olympia has a 15-year agreement with WIDCO to provide 6.5 dry tons of sludge at 16 percent solids per day. The sludge will be used as a part of WIDCO's soil reclamation program (Kolby pers. comm.).

City of Everett. The Everett treatment plant provides secondary treatment with aeration lagoons. The lagoons have not been dredged in the past, and therefore a sludge disposal method has not been necessary. The City is planning a lagoon dredging project followed by landspreading on city-owned land (Olivers pers. comm.).

City of Bremerton. Bremerton has two primary treatment plants serving a population of approximately 35,000. Sewage sludge is anaerobically digested and then applied to forestland as a fertilizer. Approximately 1,500 gallons of sludge are applied per day to 320 acres of forestland owned by the McCormick Land Company (Proctor pers. comm.).

City of Lynnwood. The City of Lynnwood provides primary treatment for about 26,000 people. The sludge collected is incinerated and the ash is landfilled.

Metro's Existing Sludge Management Methods

Introduction

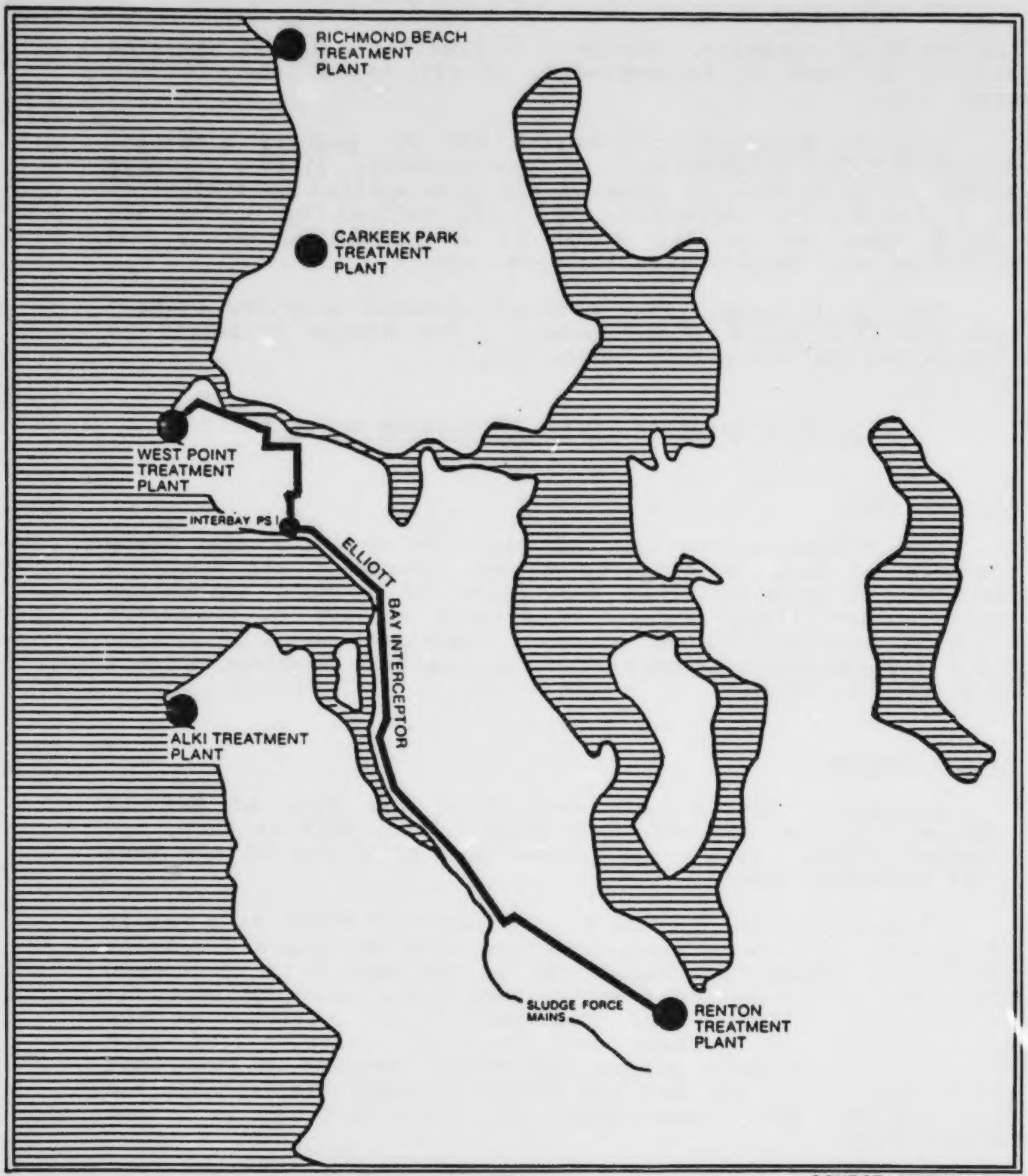
The following sections of the EIS describe the basic features of Metro's existing sludge treatment and handling methods. A more detailed discussion of Metro's wastewater treatment and sludge management systems appears in the Draft Sludge Management Plan and Technical Memorandum No. 1 of Metro's Draft Wastewater Management Plan for the Lake Washington/Green River Basins (1979a).

Sludge Treatment

Existing. Sludge is generated at all five of Metro's treatment plants: Renton, West Point, Alki, Carkeek Park, and Richmond Beach. Sludge management is centralized at the West Point Treatment Plant.

Sludge generated at the Renton Treatment Plant as a result of primary treatment (sedimentation) and secondary treatment (activated sludge) is transported to the West Point Treatment Plant via a combination sewage/sludge force main (Elliott Bay Interceptor) (Figure 2-2). Digested sludge generated at the Alki, Carkeek, and Richmond Beach Treatment Plants, all of which are primary treatment plants, is either trucked to the West Point plant or to the Interbay Pumping Station for transfer via the Elliott Bay Interceptor to the West Point plant (Figure 2-2).

All sludge generated at the West Point Treatment Plant or received there from the four other treatment plants is anaerobically digested and dewatered to 18 percent solids. Figure 2-3 presents a flow diagram of Metro's existing sludge treatment and disposal facilities.


RICHMOND BEACH TREATMENT PLANT
CARKEEK PARK TREATMENT PLANT
WEST POINT TREATMENT PLANT
INTERBAY PS I
ELLIOTT BAY INTERCEPTOR
ALKI TREATMENT PLANT
SLUDGE FORCE MAINS
RENTON TREATMENT PLANT

SOURCE: METRO,1983 a

FIGURE 2-2

Metro's Wastewater Treatment Plants and Sludge Transfer Facilities

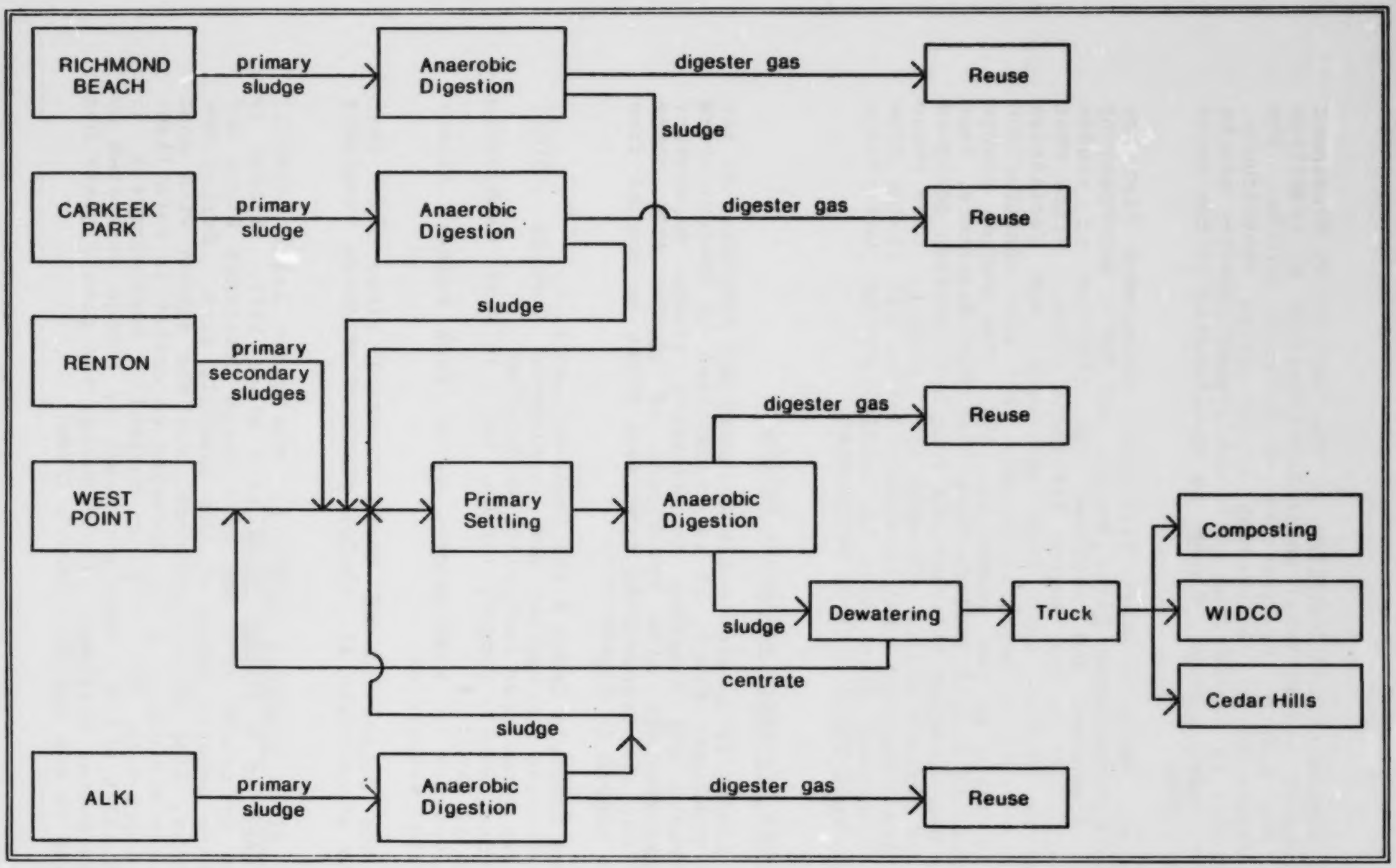

RICHMOND BEACH
primary sludge
Anaerobic Digestion
digester gas
Reuse
sludge
CARKEEK PARK
primary sludge
Anaerobic Digestion
digester gas
Reuse
sludge
RENTON
primary secondary sludges
digester gas
Reuse
WEST POINT
Primary Settling
Anaerobic Digestion
Composting
sludge
Dewatering
Truck
WIDCO
centrate
Cedar Hills
sludge
ALKI
primary sludge
Anaerobic Digestion
digester gas
Reuse

FIGURE 2-3
Flow Diagram of
Metro's Sludge Treatment and Disposal Processes

Sludge treatment and handling at the West Point Treatment Plant consists of conventional anaerobic digestion to stabilize the sludge and reduce the quantity of volatile solids. The sludge is dewatered to 18 percent solids using centrifuges. Dewatered sludge is transferred to 30-cubic-yard capacity trucks via a hopper loader system. Sludge is then trucked to the reuse or disposal sites.

Scheduled. Metro's Draft Wastewater Management Plan for the Lake Washington/Green River Basins and EPA's accompanying EIS (1980) discussed and analyzed the addition of sludge handling facilities at the Renton Treatment Plant. Since that time predesign studies have been completed, and facilities design is scheduled to begin in January 1983 with construction scheduled to begin in the summer of 1984. The Renton sludge handling facilities will include four anaerobic digesters, four thickeners, one blending digester and four belt presses designed to provide 20 percent solids (Hammond pers. comm.). Once these facilities are completed (approximately 1987), all sludge from the Renton Treatment Plant will be handled onsite, and sludge transport to West Point will be eliminated.

Present Sludge Transport and Reuse Methods

After sludge is anaerobically digested and dewatered at the West Point Treatment Plant, it is transferred to 30-cubic-yard capacity trucks for transfer to existing sludge management sites. Approximately nine truckloads of sludge (250 cubic yards) per day are transported from West Point to one of five reuse sites mapped in Figure 2-4:

- King County's Cedar Hills Regional Landfill
- Washington Irrigation and Development Company (WIDCO) strip mines near Centralia, Washington
- Sawdust Supply Company (GroCo, Inc.) in Kent, Washington
- Duvall Landfill
- University of Washington's C. L. Pack Forest, Eatonville, Washington

To date, the capacities of those disposal sites have been adequate to accommodate all sludge produced at Metro treatment plants.

Cedar Hills Regional Landfill. The Cedar Hills landfill has been used as a sludge reuse site since 1973. Sludge is transported by trucks from the West Point Treatment Plant and unloaded into holding ponds at the landfill site. During the summer months, King County personnel mix the sludge with sand and apply the mixture as a top dressing to assist in establishment of vegetation for erosion control. Approximately 49 percent (5,652-6,653 dry tons per year) of sludge generated by Metro's wastewater treatment plants during the past 3 years has been applied to the landfill (Metro 1983a).

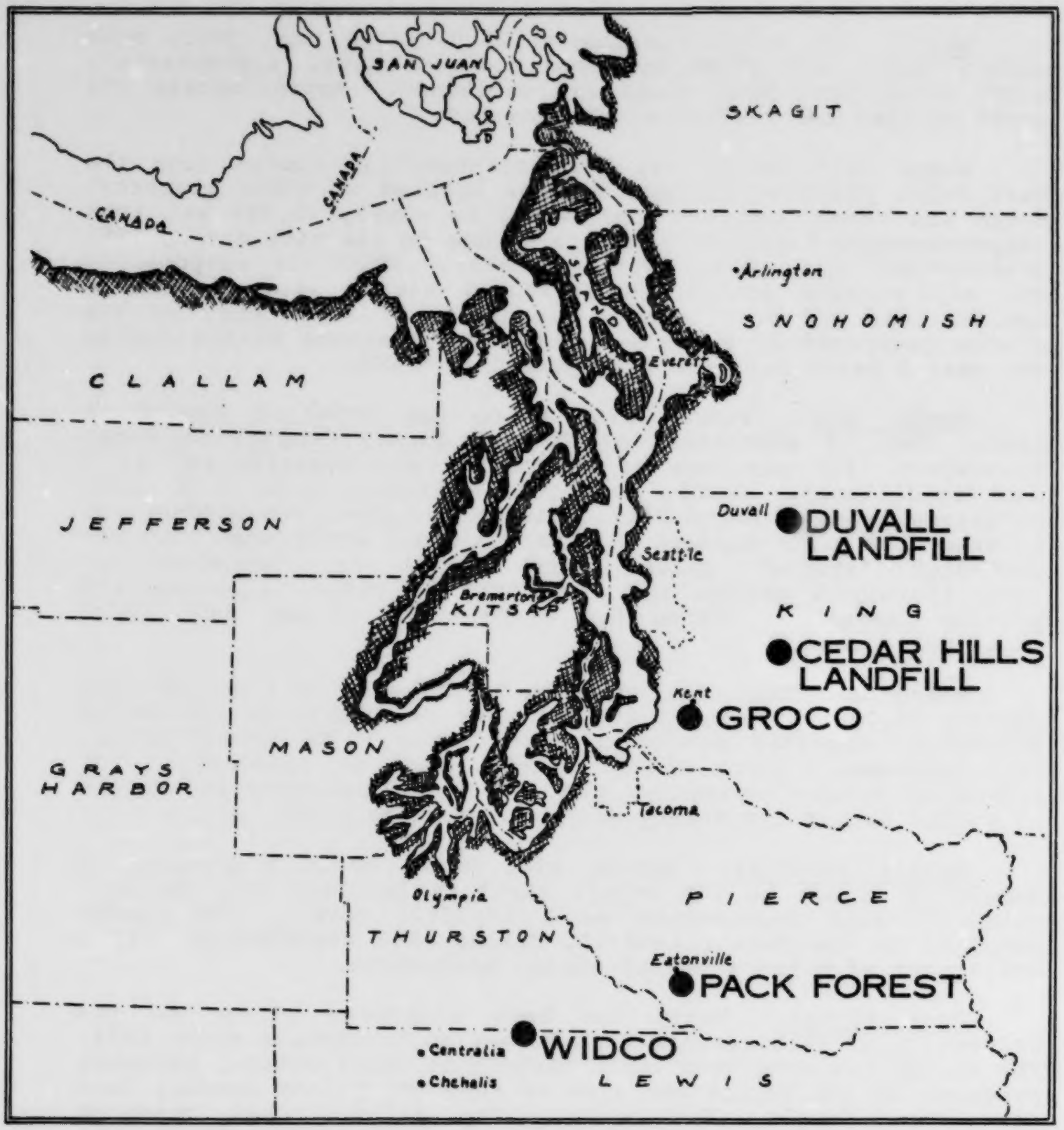

SAN JUAN
SKAGIT
CANADA
CANADA
ISLAND
Arlington
SNOHOMISH
Everett
CLALLAM
JEFFERSON
Duvall
DUVALL LANDFILL
Seattle
Bremerton
KITSAP
KING
CEDAR HILLS LANDFILL
Kent
GROCO
MASON
GRAYS HARBOR
Tacoma
Olympia
PIERCE
THURSTON
Eatonville
PACK FOREST
Centralia
WIDCO
Chehalis
LEWIS

FIGURE 2-4

Existing Sites for Reuse of Metro Sludge

WIDCO. The WIDCO operates a 22,000-acre coal strip mine within Lewis and Thurston Counties. To date, approximately 3,300 acres have been mined and reclaimed. Approximately 250 acres of land are surface-mined annually.

Since 1978, Metro has been transporting sludge from the West Point plant to storage lagoons located on WIDCO property. Metro was under contract with WIDCO to supply 22,000 wet tons (approximately 3,800 dry tons) of sludge to the site during 1982 (Metro/WIDCO Agreement, February 1982). WIDCO is responsible for all on-site activities including sludge storage, sludge application, and monitoring. Approximately 32 percent of the sludge generated by Metro's wastewater treatment plants during the past 3 years has been transported to WIDCO.

GroCo, Inc. Since 1976, Metro has supplied sludge to GroCo, Inc., a subsidiary of Sawdust Supply Company of Kent, Washington, for purposes of composting and distribution as a soil conditioner. GroCo, Inc. owns a 12-acre site in a heavy industrial area of North Kent. Sludge is mixed with sawdust (at a ratio of 3 parts sawdust to 1 part sludge) and placed into 50-foot-high "static" piles. The sludge is composted for approximately 6 months and then sold to public agencies and private landscaping firms for $7.00 to $9.50 per cubic yard (Moss pers. comm.).

Metro was under contract with GroCo, Inc. to transport and deliver 15,000 wet tons (3,000 dry tons at 20 percent solids) of dewatered, digested sludge to GroCo during 1982 (Metro/GroCo, Inc. Agreement, March 1982). GroCo, Inc. is responsible for providing storage space for the sludge and assuring protection of public health and safety at the composting site.

Duvall Landfill. During 1982 Metro began a program of supplying sludge to the Duvall sanitary landfill for the purposes of soil improvement as a landfill cover. The sludge supplied to the Duvall landfill during 1982 represented only a small part of Metro's annual sludge production.

Pack Forest. Metro has been supplying sludge to the University of Washington's Pack Forest in Eatonville since 1974. The sludge has been used for a variety of silvicultural research programs at the forest and also at Pope and Talbot Company land near Port Gamble, Washington. The silvicultural research studies have generated a significant amount of data on the response of trees to sludge application and have led to publication of a series of University of Washington bulletins entitled Use of Dewatered Sludge as an Amendment for Forest Growth.

During 1982, Metro transported and delivered 55 wet tons of sludge to storage lagoons at the Pack Forest. Since 1979, approximately 10 percent of Metro sludge has been utilized on 120 acres of forest lands.

Past Sludge Disposal and Reuse Methods

From 1966 to 1972, Metro disposed of digested sludge by discharge through the West Point effluent outfall into Puget Sound. Ocean disposal was discontinued in 1972 because of federal and state policies discouraging ocean disposal of sludge. A sludge lagoon at the West Point Treatment Plant was used for sludge storage following discontinuation of sludge disposal to Puget Sound in 1972.

In the early- and mid-1970s, Metro began a series of demonstration and soil improvement projects throughout Seattle with the cooperation of the University of Washington and Washington State University. Table 2-1 indicates the locations and dates of those past projects. One outcome of those demonstration projects was a number of research reports pertaining to public health issues, impacts of sludge application on wildlife, sludge composting, and results of applying sludge to forest and agricultural land.

Pretreatment and Source Control

One important component of Metro's wastewater treatment and sludge management programs is the pretreatment and source control program. The purpose of the program is to require industrial dischargers to meet certain limits for the discharge of toxicants and heavy metals into Metro's wastewater system. Metro has established discharge limitations that must be met by industries. Industries therefore have installed pretreatment processes to reduce the quantities of metals and other pollutants prior to discharge into the Metro system. Metro presently conducts an intensive discharge sampling and monitoring program to ensure compliance with established limits.

Metro's pretreatment and source control program is important to sludge management because a majority of the heavy metals (70-90 percent) discharged from industries into the Metro system are removed from effluent during wastewater treatment and transferred to Metro sludge. Therefore, if greater amounts of heavy metals can be removed from industrial effluents prior to discharge to Metro's system, the concentrations of trace metals in Metro's sludge will be reduced as well, thus increasing the feasibility of beneficial sludge reuse.

A more detailed description of Metro's pretreatment and source control program appears in Metro's NPDES Special Study of Heavy Metal Loads in Renton and West Point Treatment Plants (1979b). Also, Metro has initiated a Toxicant Pretreatment Planning Study (TPPS), designed to identify sources of toxicants within Metro's wastewater collection system. Preliminary results of the study have been included in Metro's Sludge Management Plan (1983a); however, the project is not scheduled for completion until mid-1983 (Hilderbrand pers. comm.).

Table 2-1. Metro's Past Sludge Disposal and Demonstration Programs

Project Name	Date	Purpose
Puget Sound Outfall	1966-1972	Disposal
Cedar Hills Landfill	1973-present	Soil improvement-landfill cover
Midway Landfill	1981	Soil improvement-landfill cover
Duvall Landfill	1982-present	Soil improvement-landfill cover
Gas Works Park	1974	Soil improvement-park development
Myrtle Edwards Park	1975	Soil improvement-park development
Boeing Air Field	1979-present	Soil improvement-turf enhancement
WIDCO coal mine	1978-present	Soil improvement-Centralia strip mine restoration
Grouse Ridge Gravel Pit	1978-1979	Soil improvement-gravel pit restoration
South Seattle Community College	1980	Soil improvement-arboretum development
West Point Sludge Lagoon	1968-1981	Beachfront earth fill (lagoon removed, 1981)
University of Washington Pack Forest	1974-present	Forest land application - University research forest near Eatonville
Pope and Talbot	1973	Forest land application - Douglas fir stands near Port Gamble
Pilchuck Tree Farm Christmas Trees	1980	Forest land application - Christmas tree plantation near Arlington
Washington State University Field Stations	1975	Agricultural application - field research stations at Mt. Vernon, Kent and Puyallup
GroCo Compost	1976-present	Composted sludge/sawdust product

SOURCE: Metro 1983a.

Existing Metro Sludge Characteristics

Sludge Quantities

Table 2-2 indicates the quantities of sludge produced daily and annually at the West Point facility from 1978 through 1982. As previously mentioned, all sludge generated at Metro treatment plants is processed at the West Point plant. Figure 2-5 shows the amounts of sludge sent to the West Point plant from the Renton plant for the period January 1978 through March 1980. Renton Treatment Plant sludge makes up approximately 40 percent of the influent suspended solids to the West Point plant (EPA 1980a).

As indicated in Figures 2-5 and 2-6, there is a substantial seasonal variation in sludge production. Several factors appear to cause the seasonal differences: 1) solids accumulated in interceptor systems during the dry summer months are flushed out during the wet season, 2) more solids are brought into the combined sewage/storm system during the wet months, and 3) solids have been found to settle out more readily during the winter months (Metro 1983a; Uchida pers. comm.). The seasonal change in sludge production affects the sludge transportation, storage and distribution needs.

Sludge production is projected to increase substantially by the year 2000. Figure 2-7 depicts the quantities of sludge projected to be generated by Metro by the year 2000, assuming a 2.6 percent annual increase in sludge volume from 1985 through 2000 (Metro 1983a). This assumed increase is based on: 1) projected population growth within the service area and, 2) secondary wastewater treatment at the Renton Treatment Plant and continued primary treatment at the West Point Treatment Plant. Any changes in expected population growth and discharge requirements would affect the projected future sludge quantities.

Sludge Quality

Monitoring of sludge quality parameters such as trace metals (e.g., cadmium, chromium, lead), pH, nutrients (nitrogen, potassium, and phosphorous), trace organics (e.g., PCBs, DDT) and pathogens is important to determine the allowable methods of sludge reuse or disposal.

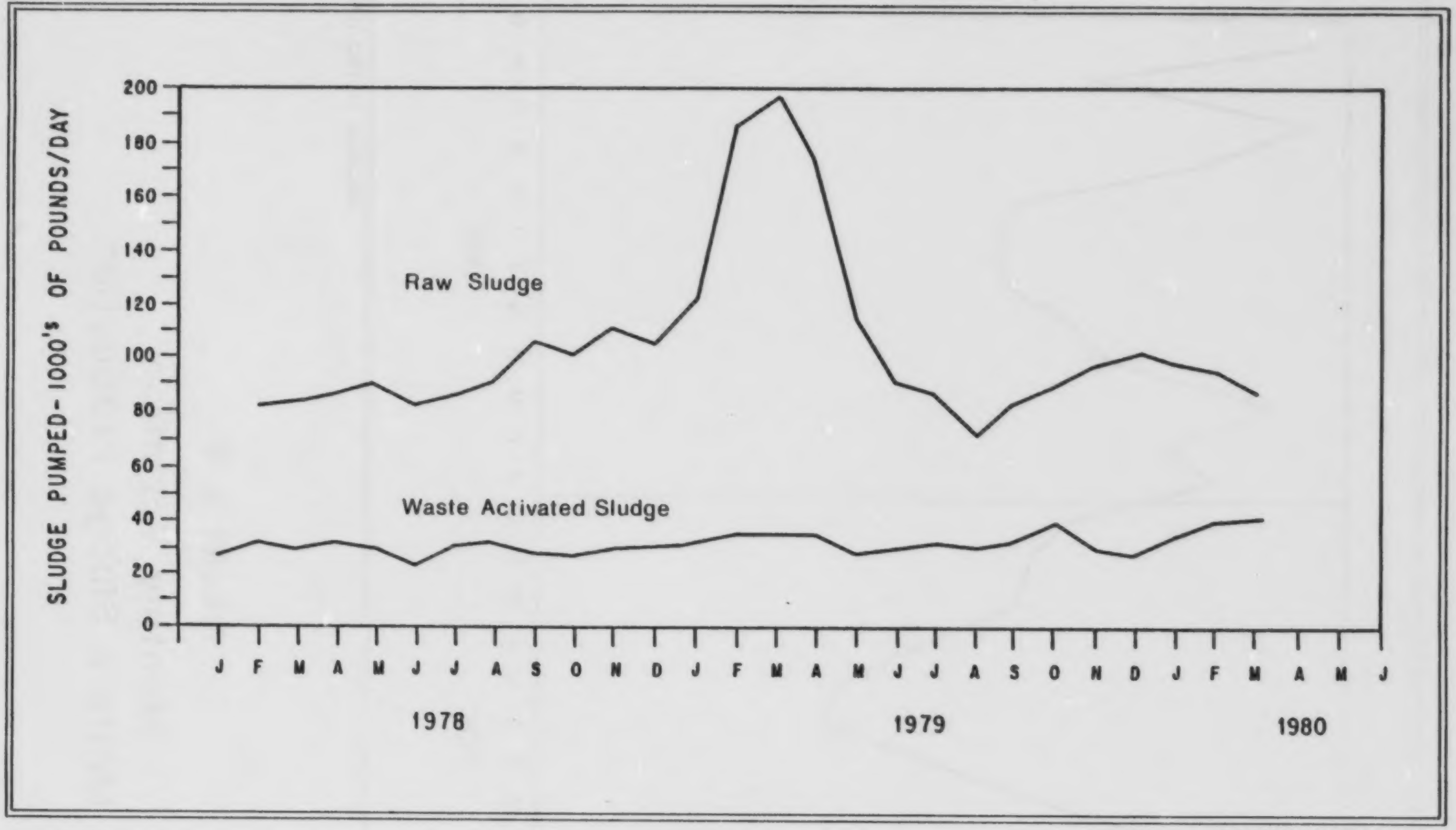
During 1981, Metro began an intensive program to monitor the physical, chemical, and microbial characteristics of sludge from the Renton and West Point Treatment Plants. The monitoring program was carried out from May 27 to September 2, 1981 and was designed to provide Metro with an accurate analysis of the sludge and an understanding of the variability of sludge quality over time. A list of the sludge monitoring parameters is presented in Appendix B of this EIS. A detailed description of

Table 2-2. Metro Sludge Quantities
1978-1982

Units/Year	1978	1979	1980	1981	1982
Dry tons of digested sludge per day (annual average)	20.2	27.9	31.6	37.2	35.1
Percent increase over previous year		38.2	13.1	17.7	<4.7>[1]
Wet cubic yards of digested sludge per day (annual average)	142.6	197.8	210.0	247.6	256.9
Number of truck loads per day (30 cu. yd. capacity)	5	7	7	8	9
Total dry tons of digested sludge	7,300	10,200	11,540	13,585	6,412[2]

NOTES: [1] < > indicates a decrease.
[2] Six-month period only (January through June).

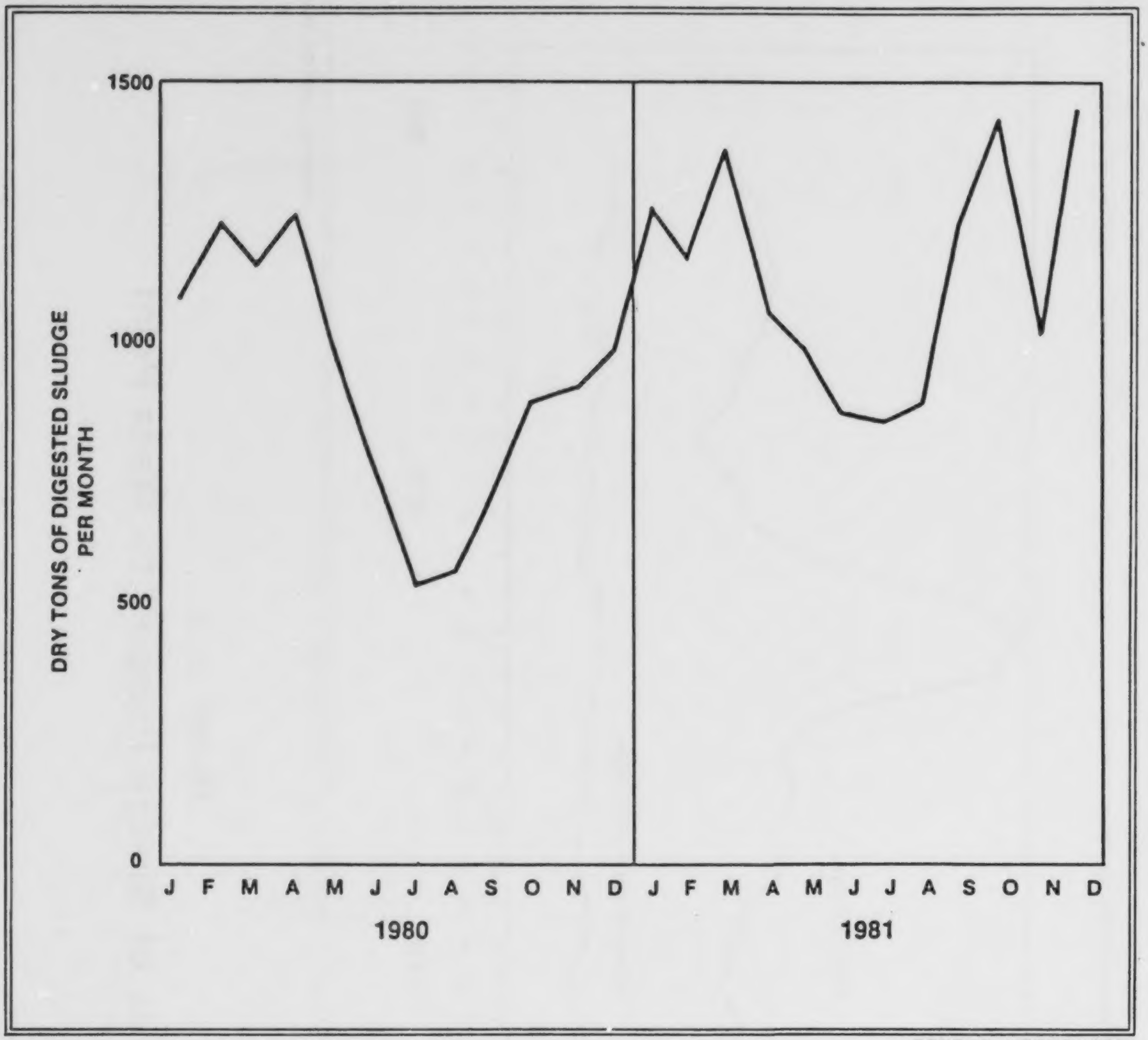
SOURCE: Metro 1983a.



SOURCE: METRO, 1980a

FIGURE 2-5

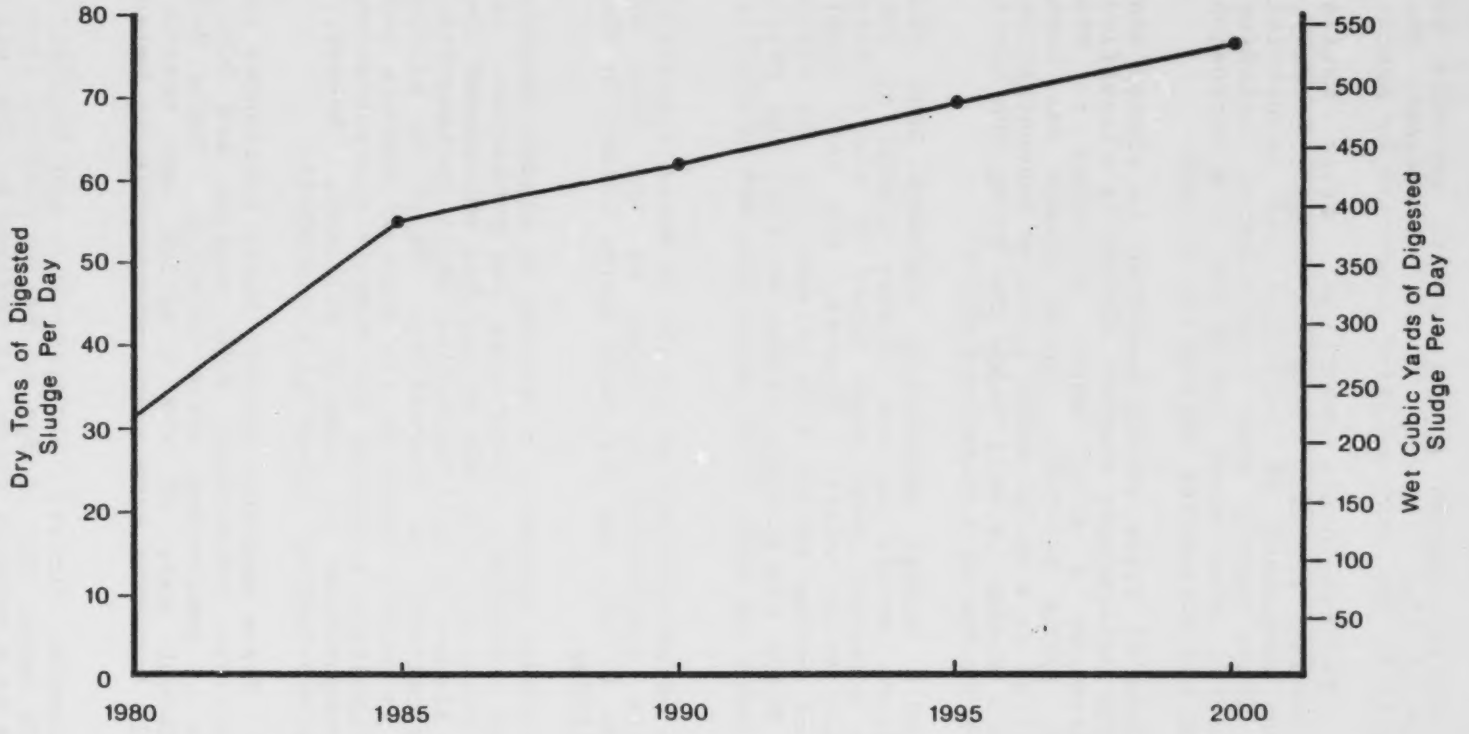
Pounds of Sludge Pumped to West Point



SOURCE: METRO,1983a

FIGURE 2-6

Monthly Variation in Metro's Sludge Production



SOURCE: METRO, 1983a

FIGURE 2-7

Summary of Future Sludge Quantity
(Dry Tons and Wet Cubic Yards per Day)

Metro's sludge monitoring program appears as an appendix to Metro's Sludge Management Plan (1983c). Table 2-3 presents the results of the May 1981 to May 1982 sampling conducted by Metro.

Trace Metals. As previously mentioned, trace metals (e.g., lead, zinc, cadmium, arsenic, chromium, copper, mercury, and nickel) are one component of municipal and industrial wastewater sludge. These metals come from sources including industrial contributions, urban storm runoff and from corrosion of water distribution and wastewater collection systems.

The concentrations of trace metals measured in sludge are one characteristic for determining whether sludge is classified as a hazardous waste or a solid waste according to EPA regulations (40 CFR, Parts 260-265). Metro sludge has been tested and is classified as a solid waste (cadmium concentration of 46 mg/kg in Metro's sludge is well below the mg/kg EPA limit which would establish sludge as a hazardous waste).

Data from Metro's sludge monitoring indicate that the concentrations of trace metals in raw primary sludge at the Renton facility are somewhat lower than those in raw primary sludge from the West Point Plant. However, the West Point values are a blend of Renton sludge (raw primary and raw waste activated) and West Point raw primary sludge so that the metal concentrations of sludge at West Point alone are not presently known.

In general, the concentrations of metals in Metro digested, dewatered sludge are comparable to those of the City of Portland, Oregon (EPA 1979b), and for other major cities in the United States (EPA 1979a).

Nutrients. Nutrients typically occurring in sludge include nitrogen (organic and ammonium), phosphorous and potassium. It is because of these nutrients that EPA policy has encouraged the beneficial reuse of sludge by land spreading (soil reclamation, silviculture or agriculture) or composting. Prior to sludge digestion, nitrogen is mainly found in the form of ammonia and organic nitrogen. Digestion increases the ammonia concentration due to partial decomposition of organic nitrogen. However, dewatering removes a substantial amount of the ammonia.

Trace Organics. Trace organics include toxic substances as pesticides and herbicides (chlordane, DDT, endrin) and PCBs. Metro has a program of monitoring trace organics. Table 2-3 indicates that although many of the organics are tested, concentrations of all but PCBs have been undetectable in Metro sludge.

Pathogens. Bacteria, viruses, and parasites are typically found in sludge. In order for sludge to be applied to land, it must be subjected to a process which, as defined by EPA, will "significantly reduce pathogens" (40 CFR, Part 257).

Table 2-3. Existing Sludge Physical, Chemical, and Microbial Quality
(Mean Values, May 1981 - May 1982)

	West Point		Renton	
	Raw Primary	Digested, Dewatered	Raw Primary	Raw Waste Activated
Flow - metric tons (dry wt.) per day	72.2	36.5	23.8	16.1
Total solids (percent of wet wt.)	5.7%	18.4%	1.05%	0.33%
pH	5.3	7.4	6.4	7.1
Nutrients (percent of dry wt.)				
Organic - N	4.5%	3.4%	4.10%	8.26%
Ammonium - N	0.28%	0.9%	0.25%	0.51%
Total - P	1.06%	1.5%	1.12%	2.86%
Total - K	0.18%	0.15%	0.48%	0.90%
Trace metals (mg/kg)				
Arsenic	6.7	14.0	4.4	6.4
Cadmium	25.0	46.0	10.2	19.4
Chromium	240.0	390.0	154.0	287.0
Copper	730.0	1,160.0	420.0	997.0
Lead	420.0	720.0	185.0	280.0
Mercury	3.3	6.2	2.80	3.1
Nickel	110.0	155.0	56.0	91.0
Zinc	1,080.0	1,780.0	666.0	644.0
Trace organics (mg/kg)				
PCBs	1.4	1.6	0.6	0.5
Chlordane	ND*	ND*	ND*	ND*
Dieldrin	ND*	ND*	ND*	ND*
DDT	ND*	ND*	ND*	ND*
Aldrin	ND*	ND*	ND*	ND*
Endrin	ND*	ND*	ND*	ND*
Lindane	ND*	ND*	ND*	ND*
Methoxychlor	ND*	ND*	ND*	ND*
Toxaphene	ND*	ND*	ND*	ND*
2,4-D	ND*	ND*	ND*	ND*
2,4,5-TP (Silvex)	ND*	ND*	ND*	ND*
Bacteria (geometric mean; n = 12-16)				
Total coliform (mpn/100g wet)	.38E10*	.23E9	.19E10	.30E9
Fecal coliform (mpn/100g wet)	.16E9	.20E8	.13E9	.24E8
Fecal streptococcus (mpn/100g wet)	.58E8	.33E8	.22E8	.76E7
Salmonella (mpn/100g wet)	.33E3	.95E2	.65E2	.60E2
Shigella (mpn/100g wet)	<.3E2	<.3E2	<.3E2	<.3E2
Yersinia (mpn/100g wet)	.20E4	.15E4	.58E3	.36E3
Virus (geometric mean; n = 11)				
Total virus (pfu/100g wet)	100.0	8.0	101.0	30.0
Parasites (no. of positive identifications)				
Giardia	1/16 samples	1/16 samples	2/10 samples	1/10 samples
Coccidia	2/16 samples	4/16 samples	1/10 samples	0/10 samples
Ascaris	0/16 samples	3/16 samples	0/10 samples	0/10 samples

SOURCE: Metro 1983a.

* E = Exponential base 10.

Anaerobic digestion is a process which can reduce pathogens by 95-99 percent. Table 2-3 identifies the results of bacteria, virus, and parasite monitoring at the West Point and Renton treatment plants. A detailed analysis of the pathogens normally found in sludge can be found in Appendix A of this EIS and in Metro's Sludge Intensive Monitoring Report (1983c).

Future Sludge Quality. The future quality of Metro sludge will rest on a number of factors:

- Potential changes in industrial pretreatment standards.
- The possibility of separating industrial wastewater flows from municipal flows.
- Success of the City of Seattle Water Department's pipe corrosion control program.
- Changes in sludge processing at Metro's treatment plants.

Such changes could provide Metro sludge with lower concentrations of trace metals which, in turn, would allow for greater flexibility in sludge management programs.

Description of Alternatives Considered by Metro

Introduction

As part of the Wastewater Management Plan for the Lake Washington/Green River Basins, Metro initiated an analysis of sludge disposal and reuse options. The process began with the Long Range Utilization Project Work Plan prepared by Metro in 1980, followed by a Cost Effectiveness Analysis of Systemwide Sludge, which was subsequently updated in 1982.

The 1980 Metro work plan included ten options for sludge disposal or reuse. The ten basic options were expanded to 16 options in Metro's 1980 cost-effectiveness analysis. In September 1982, Metro determined that an update of the 1980 cost-effectiveness analysis was necessary since a number of basic assumptions and conditions regarding sludge management had changed since 1980.

The broad categories of sludge management considered in the 1982 cost-effectiveness analysis and analyzed in this EIS include:

- Agriculture
- Composting
- Dry Sludge Product
- Incineration
- Landfilling
- Ocean Disposal
- Silviculture
- Soil Improvement

A necessary feature for all the above sludge management categories is sludge processing at the West Point or Renton treatment plants. Sludge processing components include sludge thickening, anaerobic digestion, and dewatering to either 18 or 40 percent solids content. Many of the necessary sludge processing facilities currently exist at the West Point Treatment Plant. Because of the lack of existing sludge processing at the Renton Plant, Metro's alternatives analysis has included a greater number of sludge management alternatives for Renton than considered for West Point.

Description of All Alternatives

From the 10 broad categories of sludge management previously mentioned, Metro defined 18 project alternatives; one agricultural application alternative, four composting alternatives, one dry sludge product alternative, three incineration alternatives, two land-filling alternatives, one ocean disposal alternative, four silvicultural alternatives, and two soil reclamation alternatives. Table 2-4 presents a summary description of the alternatives and their present worth costs. The apparent least cost alternative for the Renton plant assumes ocean disposal, a method no longer allowed because of the Marine Protection, Research, and Sanctuaries Act; the most costly alternative (Alternative 3) calls for construction and operation of a facility to produce a dry sludge product for sale as a soil conditioner. For the West Point plant, the least cost alternative is soil improvement at a public/private site located within 10 miles of the treatment plant (Alternative 8a); the most costly alternative (Alternative 8c) is to a site within a maximum distance (180 miles) of the treatment plant.

Metro's Screening and Selection Process

Metro's selection of alternatives for final consideration was accomplished by conducting analyses of monetary (capital costs, operation and maintenance costs, and land costs) and nonmonetary (environmental factors, energy use considerations, and subjective factors such as reliability, flexibility, and agency and public acceptance) factors. A detailed account of the alternatives analyses is presented in the Sludge Disposal and Reuse Cost-Effectiveness Evaluation (1983b), part of Metro's Draft Sludge Management Plan (1983a). As a result of the screening and evaluation process, Metro defined alternatives as either rejected, deferred, or recommended for further consideration.

Alternatives Rejected or Deferred by Metro

Of the 18 initial project alternatives, five were dropped from further consideration because of high costs, unacceptable nonmonetary factors or a combination of the two. An additional

Table 2-4. Description of Long-Term Sludge Management Alternatives

Alternative	Description	Total Cost (Present Worth, Millions)
1 - Agricultural application	Primary sludge from West Point or combined primary and thickened secondary sludges from Renton (18% solids) would be trucked 45-190 miles, stored in lagoons and applied onto private agricultural land using direct subsurface injection. Land requirement is 11,000 acres for 100% of sludge produced annually.	West Point: $28.3-45.3 Renton: $74.2-83.8
2A - Tank composting (digested sludge)	Anaerobically digested sludge (18% solids) would be composted using a Turbitol Company tank composter. Processing would be done at the Renton and West Point Treatment Plants. Composted sludge would be generated at a rate of 150-190 cubic yards per day and would sell for $2.50 per cubic yard.	West Point: $46.9 Renton: $87.4
2B - Pile composting -1 18% solids -2 40% solids	Anaerobically digested sludge (either 18% or 40% solids) would be composted using pile composting. Sludge would be trucked to a 14 to 24-acre Metro facility in the Kent Valley industrial area. Composted sludge would be generated at a rate of 150-350 cubic yards per day and would sell for $2.50 per cubic yard.	West Point: $45.3-51.5 Renton: $82.8-87.5
2C - Tank composting (undigested sludge)	Primary and thickened secondary undigested sludges (18% solids) would be composted at the Renton plant using a Turbitol Company tank processing system. No anaerobic digesters would be used at the Renton plant. Composted sludge would be generated at a rate of 150-190 cubic yards per day and would sell for $2.50 per cubic yard.	West Point: NA Renton: $83.5
3 - Dry sludge product	Undigested (raw), dewatered sludge would be dried at the Renton plant using direct/indirect rotary dryers to produce a dried sludge product for use as a soil conditioner. Sludge from West Point would probably be applied to land. Metro would sell the dried product at $86.00 per ton.	West Point: NA Renton: $115.8
4A - Thermal conditioning and incineration	Undigested (raw), dewatered sludge would be thermally conditioned by a Zimpro low pressure oxidation process to form a dry sludge cake. The sludge cake would be combusted in a multiple-hearth furnace to produce steam or hot water for space heating or electricity. Ash would be disposed of at the Cedar Hills landfill. The incineration facility would be constructed at the Renton plant only.	West Point: NA Renton: $81.6
4B - Co-incineration with municipal solid waste	A non-Metro co-incineration facility would be installed at an industrial site in the Duwamish industrial area. Undigested (raw) sludge would be chemically conditioned and dewatered to a solid cake, transported by truck to the facility, and incinerated.	West Point: NA Renton: $99.1
4C - Carver-Greenfield and incineration	Metro would utilize a Carver-Greenfield method of drying and energy recovery prior to incineration.	West Point: NA Renton: $108.8
5A - Landfill - 18% sludge disposal	Anaerobically-digested and dewatered sludge (18 percent solids) would be trucked to a landfill (within 40 miles of Seattle) and disposed of with municipal solid wastes. Metro would pay the landfill owner/operator a tipping fee of $10.50 to $25.00 per wet ton of sludge.	West Point: $20.6-36.1 Renton: $72.0-81.5
5B - Landfill - 40% sludge cake disposal	Anaerobically-digested and dewatered (40% solids) sludge would be trucked to a landfill (within 40 miles of Seattle) and disposed of with municipal solid wastes. Metro would pay the landfill owner/operator a tipping fee of $10.50-$25.00 per wet ton of sludge.	West Point: $41.0-53.5 Renton: $77.6-84.5
6 - Ocean disposal	Liquid anaerobically-digested sludge would be transferred to holding tanks and then onto large barges. Once a week the sludge would be barged approximately 50 miles off the Washington coast and dumped.	West Point: $32.3 Renton: $63.9
7A - Silvicultural application - private or public forestlands with Metro-owned demonstration site	Anaerobically-digested sludge would be dewatered and trucked to storage lagoons. Sludge would be spray-applied to forestland from July through January. Approximately 41,000 acres of land (within 30-95 miles from Seattle) would be needed to handle 100% of the sludge production from 1990-2000. Sludge would be applied once during the planning period at a rate of 20 dry tons per acre.	West Point: $29. -34.1 Renton: $77.3-80.8

Table 2-4 . Cont'd.

Alternative	Description	Total Cost (Present Worth, Millions)
7B - Silvicultural application - Metro-owned poplar forestlands	Anaerobically-digested sludge (18% solids) would be applied at a rate of 10 dry tons per acre per year to 5,500 acres of hybrid poplar forestland (located within 45 miles of Seattle). Poplar would be harvested and sold to an energy producer for the generation of electricity.	West Point: $38.0-38.4 Renton: $84.7-85.9
7C - Silvicultural application - Metro-owned multiple use lands	Anaerobically-digested sludge (18% solids) would be applied once during the planning period to 26,500 acres of land (located within 45 miles of Seattle) at a rate of 10 dry tons per acre. Douglas-fir would be harvested once every 50 years, with commercial thinnings at 20, 30, and 40 years.	West Point: $48.4-48.8 Renton: $94.4-95.5
7D - Silvicultural application - private or public forestlands with Metro-owned backup site	This alternative would be the same as Alternative 7A except that Metro would purchase 2,700 acres of land to ensure that land would always be available for sludge application.	West Point: $31.9-36.2 Renton: $79.3-82.8
8A - Soil improvement - public and private land	Anaerobically-digested and dewatered sludge (18% or 40% solids) would be trucked to storage lagoons or storage sites, applied to the land and disked into the top 18-24 inches of soil. Sludge application would occur from June to September. Land would be located 10-180 miles from Seattle and owned by entities other than Metro.	West Point: 18% solids - $19.1-38.9 40% solids - $41.0-61.4 Renton: 18% solids - $72.1-83.3 40% solids - $78.2-89.4
8B - Soil improvement - land owned by WIDCO	This alternative would be the same as Alternative 8A except that land would be owned by WIDCO and Metro would pay $10 per ton of wet sludge delivered. WIDCO would be responsible for all application and monitoring aspects.	West Point: 18% solids - $27.7 40% solids - $46.6 Renton: 18% solids - $76.5 40% solids - $80.9

Cost Assumptions: Year 2000 design year truck transportation only. Electricity costs $.022-.028/KwH. Interest assumed at 7 5/8 percent ENR 4500.

Note: More detailed cost assumptions available in Metro's Sludge disposal and reuse cost-effectiveness evaluation (Metro 1983b).

four alternatives were considered as "deferred" alternatives not presently feasible for near-term implementation, but which might at some later date be more closely considered.

The rejected and deferred alternatives were as follows:

Rejected

- 2C Raw sludge composting
- 3 Dry sludge product
- 4A Thermal conditioning and incineration
- 5A Disposal into landfill, 18 percent solids
- 5B Disposal into landfill, 40 percent solids

Deferred

- 2B-2 Pile composting - 40 percent solids
- 6 Ocean disposal
- 4B Coincineration with municipal solid waste
- 4C Multiple effect drying and incineration

Alternative 2C - Raw Sludge Composting. Metro rejected this alternative because no energy would be produced to offset the energy consumed by composting. No energy would be produced because the alternatives would not include anaerobic digestion, a sludge treatment process that produces methane gas which can be used to provide heat or electrical power.

Alternative 3 - Dry Sludge Product. This alternative was rejected because of high present worth cost and the absence of anaerobic digestion to recover energy.

Alternative 4A - Thermal Conditioning with Incineration. Metro rejected this alternative because of the large net amount of energy required for operation and because many thermal conditioning facilities have been shut down across the country because of reliability, odor, or other operational problems.

Alternative 5A - Disposal into Landfill, 18 Percent Solids. Metro rejected Alternative 5A for the reasons defined in Alternative 5B.

Alternative 5B - Disposal into Landfill, 40 Percent Solids. Metro rejected Alternative 5B because of the higher costs associated with dewatering sludge to 40 percent, the lack of beneficial sludge reuse, and opposition from landfill owners.

Alternative 2B-2 - Pile Composting, 40 Percent Solids. Metro deferred this alternative because pile composting using 40 percent solids provided no savings in transportation energy costs when compared to pile composting with 18 percent solids. However, the alternative might be reconsidered at a future date when the use of 40 percent solids might become more feasible.

Alternative 4B - Coincineration with Municipal Solid Waste. Metro deferred this alternative because of technical, financial and operational uncertainties.

Alternative 4C - Multiple Hearth Drying and Incineration. This alternative was deferred because of the uncertainties associated with an unproven technology.

Alternative 6 - Ocean Disposal. Because ocean disposal was judged to be the least costly alternative, Metro recommended deferral of this alternative. If the federal prohibition of ocean disposal is changed in the future, Metro would reconsider this alternative.

Detailed Description of Feasible Alternatives

Of the 18 initial alternatives evaluated by Metro, 9 were recommended for additional evaluation. These alternatives were as follows:

- Agricultural Application
    - Alternative 1
- Composting
    - Alternative 2A - Tank composting
    - Alternative 2B-1 - Pile composting, 18 percent solids
- Silvicultural Application
    - Alternative 7A - Public/private forestlands with Metro-owned demonstration site
    - Alternative 7B - Metro-owned poplar forestlands
    - Alternative 7C - Metro-owned multiple use forestlands
    - Alternative 7D - Public/private forestlands with Metro-owned backup site
- Soil Improvement
    - Alternative 8A - Soil improvement of public/private land
    - Alternative 8B - Soil improvement at WIDCO

The following sections include a general description of each broad category of sludge management (i.e., agricultural application, composting, landfilling, silviculture, and soil improvement) followed by a more detailed description of each feasible alternative being considered by Metro. The costs of these alternatives are compared in Table 2-5.

Agricultural Application. Approximately 16 percent of all sewage sludge generated in the United States is applied to agricultural land for the production of food chain crops for direct human consumption or food chain crops for animal feed (Peter *in* Bledsoe 1981). Application of sludge to agricultural land is one of the more popular methods of sludge reuse by small municipal treatment facilities having small volumes and low concentration of trace metals in sludge.

Table 2-5. Costs of Feasible Alternatives

Alternative	Capital Costs ($ million)		Year 2000 O&M Costs ($ million)[1]		Present Worth Costs ($ million)[1]	
	Renton	West Point	Renton	West Point	Renton	West Point
AGRICULTURAL APPLICATION						
Alternative 1						
- Western Washington	61.9	5.1	3.5	2.7	74.2	28.3
- Eastern Washington	61.3	5.8	5.1	4.1	83.8	45.3
COMPOSTING						
Alternative 2A (Tank composting)	83.0	32.3	2.5	1.6	87.4	46.9
Alternative 2B-1 (Pile composting - 18% solids)	77.5	23.6	2.3	2.5	87.5	45.3
SILVICULTURAL APPLICATION						
Alternative 7A (Public/private forestlands with Metro-owned demonstration site)	66.6	6.5	3.2-3.8	2.4-3.1	77.3-80.8	29.8-34.1
Alternative 7B (Metro-owned poplar forestland)	66.6	8.3	2.9-3.1	2.3-2.4	84.7-85.9	38.0-38.4
Alternative 7C (Metro-owned multiple use forest-lands)	66.6	7.2	2.9-3.2	2.5-2.6	94.4-95.5	48.4-48.8
Alternative 7D (Public/private forestlands with Metro-owned backup site)	66.6	6.5	3.2-3.8	2.4-3.1	79.3-82.8	31.9-36.2
SOIL IMPROVEMENT						
Alternative 8A (Soil improvement of public or private land)	62.1	2.8	3.2-4.9	2.3-4.1	72.1-83.3	19.1-38.9
Alternative 8B (Soil improvement at WIDCO)	62.1	2.7	3.9	3.0	76.5	27.7

NOTES: [1] Lower costs for minimum trucking distance; higher costs for maximum trucking distance.

All costs expressed as mid-1983 dollars with no inflation factor. Discount rates @ 7 5/8 percent; ENR of 4500; accuracy within +50 to -30 percent.

SOURCE: Metro 1983b.

Sludge applied to agricultural land is known to beneficially recycle nutrients (nitrogen, phosphorous, and potassium) and to improve the physical properties of soil (increased water infiltration; increased water-holding capacity and water content). For most plant varieties, sludge can provide nitrogen adequate to meet annual requirements. One ton of dry sludge solids with an organic content of 3.0 percent and an inorganic nitrogen content (NH_4^+) of 0.5 percent can provide 22 pounds of nitrogen (DOE 1982a).

EPA (40 CFR, Part 257) has identified the most critical factors for sludge application for production of food chain crops to be soil pH, sludge cadmium concentration, sludge PCB concentration, disease vector control, and pathogen reduction. For all food chain crops for direct human consumption, the soil pH must be kept at or above 6.5 unless the sludge cadmium concentration is less than or equal to 2 mg/kg. If soil pH is 6.5 or greater, up to 0.5 kg/ha (0.45 lbs/acre) of cadmium can be applied annually with a cumulative application of 5-20 kg/ha (4.5-18 lbs/acre), depending on the cation exchange capacity (CEC) of the soil (40 CFR, Part 257). CEC is defined as the ability of soil to hold positively charged cations. The CEC is expressed in milliequivalents per 100 grams of soil (meq/100 g).

Sludge can be applied to the surface or beneath the surface of agricultural land using either irrigation or tank vehicles. In the Best Management Practices for Use of Municipal Sewage Sludge the DOE (1982a) recommends that sludge be either injected into the soil, or if surface applied, it should be immediately plowed into the soil to control odors and to achieve maximum use of nitrogen.

Crops vary in their reaction to sludge-enriched soils (EPA 1976a). Some crops may take up and accumulate trace elements. As a general rule, the leafy portions of plants contain higher levels of trace metals than found in seed heads or flowers (EPA 1976a). Leafy vegetables such as lettuce, spinach, chard, and tobacco tend to accumulate heavy metals such as cadmium more than do other varieties of plants.

The DOE (1982a) has established guidelines and suggested management practices for protection of food crops:

1. Raw sludge should not be applied to agricultural land.
2. Sludge should not be applied to soil the year the soil is used for root crops unless the sludge has undergone a process to further reduce pathogens (see DOE Guidelines).
3. Sludge should not be applied to vegetables through irrigation systems, or by other methods that place sludge on the crop.
4. Whenever possible the sludge should be applied before planting, with immediate incorporation. Grain crops are preferred.

5. Sludge applied to forage land (green chop, silage, hay, or pasture) should immediately follow mowing, so that sludge is not deposited on plant leaves and subsequently ingested by livestock.
6. Sludge, soils, and plants should be subjected to a testing program that will provide background data and evaluate potential accumulation of heavy metals in soils and plants.
7. The fertilizer guide published by Washington State University for the appropriate crop should be followed to identify fertility requirements as a basis for sludge application.
8. When practical, sludge should be applied to nonfood crops such as turf, ornamentals, and Christmas trees.

Metro identified one recommended agricultural application alternatives from the 17 initial alternatives. A description of that alternative follows.

Alternative 1 - Agricultural Application -- The goal of Alternative 1 is to beneficially use stabilized, dewatered sludge to supply nitrogen and other nutrients to nondirect crops other than food chain crops for direct human consumption. Under this alternative, anaerobically-digested primary sludge from West Point and combined primary and thickened secondary sludge from Renton would be dewatered to 18 percent solids and trucked to storage lagoons at agricultural sites in western or eastern Washington. Sludge would be applied at an annual loading rate of 3.1 dry tons per acre to privately-owned agricultural land using an application vehicle equipped with a subsurface injection device. The one-way distance of agricultural land from the treatment facilities could range from 45-190 miles. Assuming an annual sludge loading rate of 3.1 dry tons per acre, approximately 6,290 acres of agricultural land would be needed to accommodate 100 percent of the projected 1985 sludge quantities.

If sludge application were to occur in western Washington, sludge would be hauled to a 100-acre storage lagoon site having a capacity of approximately 36 million gallons (equivalent of year 2000 annual sludge production). Sludge would be applied 8 months of the year. Lime would be applied every 3 years to adjust the soil pH above 6.5.

If sludge application were to occur in eastern Washington, sludge would be hauled to one of 9 storage lagoons (3.3-4.2 million gallon capacity each). Sludge application would occur 10 months per year; no liming would be necessary because pH levels of eastern Washington soils exceed 6.5.

Composting. Sludge composting involves the aerobic decomposition of organic constituents to a relatively stable humus-like material. While sludge is not rendered totally inert by composting, in-vessel or static aerated pile composting is considered by EPA to be a process to further reduce pathogens.

Composting can be accomplished in several ways: windrow method, aerated static pile method (individual or extended piles) or within enclosed containers (tanks). Although each technique is unique, the fundamental process is similar. Requirements include bulking agents (such as wood chips or sawdust), internal temperature ranging from 130-150° F. (55-65° C.) to ensure destruction of pathogens, extended-term storage of compost, and final separation of bulking agent and compost (EPA 1979a).

The composting procedure involves mixing raw or digested sludge with the bulking agent and piling the mixture in a windrow or pile or storing in an enclosed container. As the organic material decomposes, heat generated by the microorganisms will raise the temperatures in the compost pile.

Composting is common throughout much of Western Europe and to a more limited extent in the United States. The compost product is normally used as a mulch, soil conditioner, or bedding material for landscaping and nursery stock (DOE 1982a).

Metro recommended composting alternatives (2A and 2B-1) from the initial 18 alternatives. A detailed description of these alternatives follows.

Alternative 2A - Tank Composting -- Alternative 2A involves use of a Taulman-Weiss tank composting processing on Metro-owned land at the Renton and West Point treatment plants beginning in 1988. Tank composting has been utilized in Europe but not to a great extent in the United STates.

Under this alternative, anaerobically digested sludge dewatered to 18 percent solids would be mixed with wood chips or another bulking agent and placed within the bioreactor, the first of two vertical, cylindrical, enclosed Taulman-Weiss tanks. After 14 days of composting within the bioreactor, the composted sludge would be transferred to a cure reactor for 14-20 days. The entire composting process would take 28-34 days.

In order to accommodate the projected year 2000 sludge quantities, 7 bioreactors and 4 cure reactors would be needed at the Renton Treatment Plant, and 6 bioreactors and 2 cure reactors would be needed at West Point.

Alternative 2B-1 - Pile Composting, 18 Percent Solids -- Alternative 2B involves composting of anaerobically digested sludge (18 percent solids) processed at the Renton and West Point treatment plants in the same manner as previously described. Sludge would be trucked to a 24-acre composting site in the Kent Valley industrial area, stockpiled, and mixed with wood chips in a 3:1 chips-to-sludge ratio. The mixture would be placed in 10-foot-high static piles aerated from underneath using a piping and fan system. The time required for composting would be 28 days of aeration time followed by 5 days of drying. The composted product would be sold by the contractor to public and private users such as highway departments, landscapers nursery men, and possibly the general public.

Silvicultural Application. The application of sludge to forestlands is a relatively new concept. Most available information derives from studies conducted in Pennsylvania, Michigan, and Washington. The greatest amount of sludge forestland application research has been accomplished at the University of Washington's Pack Forest.

Research studies have shown that sludge is suitable for application on Douglas-fir, cottonwood, poplar, and Sitka spruce but that western hemlock, red cedar and red alder do not respond well to sludge amended conditions (DOE 1982a). Sludge can be applied to: 1) recently logged forestlands, 2) recently established plantations, or 3) well established forests using either spreading or spray application methods. Studies have shown that sludge must be allowed to dry for at least 6 months prior to planting seedlings on recently logged sites, but that sludge can be spray-applied over young established plantations (seedling age 5 years or older). Application of sludge to established forests has been studied more than other forestland options. As a part of its research program, the University of Washington has studied the nitrogen needs of forestlands in Western Washington. The research has shown that up to 43 tons of sludge per acre (approximate depth of 2 inches) is sufficient to meet the nitrogen needs of a forest site over a 5-year period (DOE 1982a).

The methods of applying sludge proven to be the most effective to date include use of a spray application vehicle mounted with a sludge storage tank and cannon-type spray nozzle for distributing sludge up to 150 feet from the vehicle. Access roads spaced 250 feet apart allow for proper sludge coverage of each site.

The DOE (1982a) has indicated a number of advantages for using forestlands in Western Washington for sludge application:

1. Extensive acreages of suitable forestland are located within a reasonable hauling distance from municipal treatment plant facilities.
2. A substantial number of these forestlands are located on well-drained sites and are not subjected to periodic flooding.
3. Many of the forestlands are markedly deficient in the nutrients found in municipal sludge, especially nitrogen and phosphorous.
4. Public health concerns and land-application regulations, particularly those related to heavy metals, are a less critical consideration for nonfood chain crops than for those used for human consumption.

5. In general, year-round application schedules can be maintained, minimizing storage needs and off-season disposal demands.

Metro identified three feasible silvicultural application alternatives: Alternative 7A, Public/private forestlands with Metro-owned demonstration site; Alternative 7B, Metro-owned poplar forestlands; and Alternative 7C, Public/private forestlands with Metro-owned backup site.

Alternative 7A - Public or Private Forestlands with Metro-Owned Demonstration Site -- This alternative calls for sludge processing at Renton and West Point consisting of thickening, anaerobic digestion and dewatering to 18 percent solids. Metro would initiate sludge application in 1985 on a Metro-owned 640-acre demonstration site. Facilities for the site would include one 36-million-gallon storage lagoon, access roads, operation buildings, fencing, one lagoon tractor, and one sludge application vehicle. Sludge would be applied at a rate of 20 dry tons per acre for each of the years 1985, 1986, and 1987. Site monitoring of soils, surface water, groundwater and plant tissue would be carried out during sludge application and for 5 years after the last application.

Beginning in 1990, Metro would initiate full-scale silvicultural application on 41,000 acres of public or privately owned land. Sludge from the Renton and West Point plants would be transported by 30-cubic-yard capacity trucks to the 36 MG storage lagoon. Sludge application would occur 9 months of each year, using lagoon tractors and pumps, 6,000-gallon-capacity nurse tankers (to transport sludge from the lagoon to the actual application sites) and application vehicles. The application sites would be located 30-95 miles from the Renton and West Point treatment plants.

Alternative 7B - Metro-Owned Poplar Forestlands -- Sludge processing for this alternative would be the same as described for Alternative 7A. This alternative assumes that Metro would purchase 5,440 acres (the 640-acre demonstration site plus 4,300 acres in 1989 and 500 acres in 1994), clear the land, plant poplar, apply sludge at 10 dry tons per acre per year, and after 7 years harvest the timber for sale as a fuel source for generation and after 7 years of electricity. The facilities and equipment needed for implementation of this alternative would include a 36 MG lagoon, 2 lagoon tractors and 3 pumps, 5 nurse tankers, and 8 sludge application vehicles. Approximately 71 dry tons of poplar would be harvested per acre per year. Revenues derived from methane recapture and sale of wood would amount to approximately $1.1 million during the year 2000.

Alternative 7C - Metro-Owned Multiple Use Forestlands -- With Alternative 7C, sludge processing would be the same as for Alternatives 7A and 7B. Metro would purchase 26,500 acres of logged forestlands to grow trees for timber revenues.

Immediately following purchase of land, 10 dry tons of sludge per acre would be applied and the site planted with a grass cover crop. During the fall, Douglas-fir seedlings would be planted on the grassy sites, and 5 years later sludge would be applied at a rate of 20 dry tons per acre.

Public access to the land would be restricted for a 1 year period after sludge application. All other land would be available for multiple use activities. The facilities and equipment needed would include 1 36 MG storage lagoon, 2 lagoon tractors, 3 lagoon pumps, 8 nurse tankers, and 8 application vehicles.

Alternative 7D - Private/Public Forestlands with Metro-Owned Backup Site -- Sludge processing for this alternative would be the same as previously described for other silvicultural alternatives. This alternative would be the same as Alternative 7A except that Metro would also purchase 2,700 acres of land as a backup site for sludge management. The same equipment and facilities needs as for Alternative 7A would be used for this alternative.

Soil Improvement. The use of sludge to improve soils deficient in nutrients and organic material has received more recognition in recent years. Surface-mined land has been reclaimed using sludge in Pennsylvania, Illinois, Washington, Minnesota, and West Virginia (Sopper and Kerr 1979; Frank in Sludge Magazine 1978). In Washington, Metro has conducted soil improvement projects at West Point Beach Park; along the Lake Sammamish interceptor right-of-way; at Boeing Field, Gasworks Park, Myrtle Edwards Park, and Grain Terminal Waterfront Park; at WIDCO in Centralia; and at the Grouse Ridge borrow pit owned by Weyerhaeuser Company (Hubbard in Bledsoe 1981).

Use of sludge for soil improvement includes sludge storage in lagoons, sludge application, disking, final grading and seeding. Application can be accomplished by: 1) spray irrigation, 2) direct dumping from haul trucks, 3) broadcast spreading with commercial fertilizer spreaders, 4) nurse trucks or pipelines attached to cultivater tools, and 5) direct soil injection by mobile all-terrain tankers equipped with rippers and injection tubes (DOE 1982a).

Sludge for use at land reclamation sites is usually held in the storage lagoons until application in the spring, summer, and fall months. Application rates vary with the site, type of soil, and other factors. Long term sludge application requires site monitoring to assess the impact of sludge application on surface water, groundwater, and soils, and to provide an early warning of any adverse impacts (DOE 1982a). Sludge application rates are typically higher than those for silviculture or agricultural uses, particularly if no sensitive groundwater and surface water resources occur near the application site.

Two soil improvement alternatives were considered feasible by Metro - Alternative 8A, Soil improvement of public or private land, and Alternative 8B, Soil Improvement at WIDCO.

Alternative 8A - Soil Improvement of Public or Private Land -- The in-plant processing for this alternative at Renton and West Point would include thickening, anaerobic digestion, and dewatering to 18 percent solids. Sludge would be trucked to a 36 MG storage lagoon holding area in the Kent Valley and thence to application sites located 35-155 miles (one-way) distance from the storage area. The storage lagoon would be sized to handle year 2000 sludge volumes.

Sludge at the application sites would be end-dumped from trucks and disked into the soil using a D-8 caterpillar tractor with an 8-foot-wide disk. A grass cover would be planted immediately after final disking. Sludge application would occur 4 months of each year at a rate of 120 dry tons/acre/year. From 220-300 acres of land would be needed each year for this alternative.

Under this alternative Metro might consider the application of sludge as a landfill cover (top dressing) at the Cedar Hills and Duvall landfills. The application of sludge as a top dressing involves mixing the sludge with soil and applying the mixture as cover material on the landfill. The cover material is then seeded with a grass seed to bind the soil and to prevent surface erosion. Best Management Practices for use of municipal sewage sludge as a landfill top dressing have been identified by the DOE (1982a).

Alternative 8B - Soil Improvement at WIDCO -- The in-plant sludge processing for this alternative would be the same as previously described for Alternative 8A. Sludge would be transported, stored, and trucked to WIDCO in much the same manner as previously described for Alternative 8A.

Sludge would be trucked year-round to sludge lagoons at WIDCO. Metro would pay a tipping fee of $10 per wet ton and WIDCO would be responsible for on-site handling and site monitoring.

Metro's Preferred Long-Range Sludge Management Program

Goals of the Preferred Plan

Metro has defined four long-range sludge management goals relevant to various components of the preferred program. These goals are to:

- Implement land application of sludge as the preferred management strategy, including soil improvement, agricultural application, silvicultural application and production, and marketing of a composted sludge product
- Continue anaerobic digestion and dewatering to 18 percent soils at the West Point Treatment Plant and incorporate the same processing at the Renton Treatment Plant.
- Identify land application sites capable of accommodating 150 percent of the projected annual sludge quantity.
- Secure land application sites at least 1 year in advance of project startup.

In addition to these broad goals, Metro has identified a number of goals specific to soil improvement, agricultural application, silviculture and compost production. These goals are listed in Table 2-6.

Elements of the Preferred Plan

In-Plant Processing. Different in-plant sludge processing methods prior to land application or composting have been described above for each of the feasible alternatives. Anaerobic digestion with medium dewatering (18 percent solids) have been identified by Metro as recommended in-plant processing.

Sludge Transport. Different sludge transport methods for land application or composting have been described above for each of the feasible alternatives. Metro has identified truck transport as the recommended transport mode.

Agricultural Application. As a part of the Preferred Sludge Management Plan, Metro proposes to initiate a program of applying sludge to agricultural land in Western or Eastern Washington. Agricultural sites as close as 45 miles and as far away as 190 miles could be cost effective.

Agricultural application could be initiated as a demonstration project as early as 1985. Project features would include:

- Sludge storage - Western Washington sludge storage would be on land purchased by Metro, whereas Eastern Washington storage facilities would be located on private agricultural land.
- Rehandling - Sludge would be removed from lagoons using manure-type pumps, followed by loading into application or nursing vehicles.
- Sludge application - Sludge would be applied using subsurface injection systems.
- Monitoring - Metro would provide soils and groundwater monitoring following sludge application.

Table 2-6. Metro's Proposed Sludge Management Goals.

PRIMARY GOALS

- Implement land application of sludge as preferred sludge management strategy. Land application methods include soil improvement, agricultural application, silvicultural application and production and marketing of a composted sludge product.
- Continue anaerobic digestion and moderate (about 18 percent solids) dewatering at the West Point Treatment Plant. Recommend that solids handling facilities at the Renton Treatment Plant be designed to provide anaerobic digestion and moderate dewatering.
- Identify land application sites capable of taking 150 percent of the projected annual sludge quantity to ensure reliable sludge management.
- Secure land application sites at least 1 year in advance of project start-up.
- Secure a Metro-owned or leased site to provide backup capacity for at least 1 year.
- Determine cost and feasibility of improving the quality of Metro's sludge by minimizing or lessening the concentrations of potentially toxic or hazardous substances entering the treatment plants by a more stringent industrial pretreatment program or by treating industrial flows separately.

AGRICULTURAL APPLICATION

- Investigate opportunities for implementing agricultural application projects.

COMPOSTED SLUDGE PRODUCT

- Maintain existing production capacity either at Sawdust Supply Company (GroCo) or at alternate public or Metro-owned site.
- Evaluate different composting methods to determine the most effective method of meeting Metro's current and projected composting needs.
- Investigate further the potential market for Metro compost.
- Implement a marketing program for sludge-derived compost to encourage use within available market. Use sludge-derived compost for landscaping at Metro transit and wastewater treatment facilities. Coordinate with local governments to use in landscaping of other government facilities.

SILVICULTURAL APPLICATION

- When possible, locate projects on land owned by private timber companies or state/federal timber management agencies.
- To provide capacity and a guaranteed site, purchase land for sludge application. Focus on land in King County.
- Implement demonstration projects to demonstrate benefits of sludge application on forest land to landowners and surrounding neighbors. Include extensive monitoring to document effects on groundwater quality, surface water quality, and wildlife populations.

SOIL IMPROVEMENT

- Maintain existing contract with Washington Irrigation and Development Company (WIDCO) for sludge use in reclamation of the strip mine site at Centralia.
- Implement additional soil improvement projects as available.

SECONDARY GOALS

- In cooperation with WDOE, investigate possibilities for regional sludge management.
- Continue to support research designed to provide better understanding of long-term fate and possible effects (beneficial and adverse) of sludge constituents in the environment.
- Investigate possibilities for developing management practices which maximize enhancement of plant growth. Investigate alternative operational systems which may provide more efficient and less costly land application methods.
- Continue to monitor regulatory status, implementation potential and other agency experience with sludge management alternatives that have been "set aside" in this document. Evaluate any new or different sludge management technologies that become available. Weigh estimated costs and potential benefits or impacts against present system. Report on any technologies with potential for Metro implementation to the Water Quality Committee of the Metro Council.

Metro would begin full-scale sludge application following the initiation and review of the demonstration projects.

Silvicultural Application. A second component of Metro's preferred plan includes application of sludge onto forestlands within a distance of 30-95 miles from Metro's treatment plants. Application could be accomplished on private, public or Metro-owned land (if within 45 miles of the Renton or West Point treatment plants). Project features would include:

- Sludge Storage - Sludge would be stored in lagoons located no greater than 0.75 miles from application sites.
- Rehandling - Sludge pumps and nursing vehicles would be needed for sludge rehandling. Sludge would be pumped from lagoons into nursing trucks having 6,000-gallon capacities. Sludge would be moved in the nursing vehicles to the application sites and then transferred to spray application vehicles.
- Sludge Application - Sludge from the nursing vehicles would be transferred to 2,000-gallon capacity, all-terrain spray application vehicles. Those vehicles would spray sludge into the forest from skidder trails spaced 150-300 feet apart.
- Monitoring - Metro has prepared a Sludge-Intensive Monitoring Report and a draft monitoring program response plan for a silvicultural application demonstration program to be initiated at the Pilchuck Tree Farm, Arlington, Washington. Results of this demonstration program will provide Metro with guidance needed to establish monitoring needs for the long-range program.

Full-scale silvicultural application is not anticipated to begin until 1990; however, demonstration projects are planned to be initiated in the fall of 1983. A description of the first demonstration project, at the Pilchuck Tree Farm, appears in the discussion of Metro's near-term plan.

Soil Improvement. The third component of Metro's preferred plan is to utilize sludge for improvement of soil on disturbed land located within 10-180 miles from Metro's treatment plants. Metro would utilize DOE's Best Management Practices to determine suitable sites. Features of soil improvement would include:

- Storage - Metro would either develop a central storage lagoon or utilize on-site storage capabilities.
- Rehandling - Sludge would be moved from storage lagoons to nursing vehicles using a sludge pump and tractor. Nursing vehicles would transport sludge to the application sites, and sludge would be off-loaded by use of an end-dumping method.
- Application - Sludge would be incorporated into the soil using a disk plow pulled by a caterpillar tractor.
- Monitoring - Site monitoring would be the responsibility of Metro or the site owner/operator.

Production and Marketing of a Composted Sludge Product. The fourth component of Metro's preferred long-term plan is development of a composted sludge product to be marketed and used as a soil amendment, mulch, or fertilizer substitute. Metro has identified two possible methods of sludge composting, tank (enclosed vessel) and pile systems; these systems were previously discussed in this chapter.

Metro would have the choice of owning and operating a compost operation or contracting with a private party for those services. Because a composting methodology has not been selected, Metro proposes to initiate a number of studies to assist in the decision, including:

- An economic study of ownership of vs contracting for the compost facility.
- An evaluation of composting methodologies.
- A market study to establish market capacity and price for a composted product.

Steps to Plan Implementation. Metro has identified four steps necessary prior to implementation of the preferred sludge management plan. These steps would be necessary for any land application of sludge.

1. Develop and finalize key evaluation criteria to determine site acceptability.
2. Develop an inventory of possible sludge application sites located within a cost-effective distance of Metro's Renton and West Point treatment plants.
3. Evaluate and prioritize sites based on DOE's Best Management Practices for use of municipal sewage sludge.
4. Initiate detailed site selection process.

Metro's Preferred Near-Term Plan

In addition to the long-range (20-year) plan, Metro's sludge management planning effort includes a 5-year and a 1-year (1983) planning period. Each is designed to provide a more site-specific analysis of sludge management projects and sites.

Five-Year Plan

Metro's five year plan will include the following subject areas:

- Plan Objectives
- Quantities and Characteristics of Sludge
- Project Identification Methods
- Evaluation Procedures
- Project Implementation

The five-year plan will present a list of potential projects capable of taking all of the estimated sludge production during the planning period plus a list of sites that could handle up to an additional 50 percent of the sludge in the event the preferred sites cannot be utilized. Metro has established a goal of using 35 percent of the sludge production for soil improvement; 25 percent for composting; 25 percent for silviculture; and 15 percent for agricultural use.

The five-year plan has not yet been prepared and therefore is not evaluated in this EIS. It will, however, be presented in Metro's final plan and evaluated in the Final EIS.

1983 Plan

Summary of Plan. Metro has identified five permitted sludge application sites and a number of sites for which permits have not been granted to handle the projected 1983 sludge volume of 77,700 wet tons (13,986 dry tons). The permitted sites include:

o	WIDCO	38,000 wet tons (wt)
o	GroCo	4,000
o	Cedar Hills Landfill	15,000
o	Duvall Landfill	3,000
o	Pack Forest	2,000
		62,000

Other sites which have not yet received permits would be needed to accommodate the additional 15,700 wt of sludge. One site at the Pilchuck Tree Farm, currently in the permitting process, may accommodate 8,000 wt of sludge during 1983. Other sites may accommodate the following:

o	Soil Improvement	12,000 wt
o	Agricultural Application (pasture land)	10,000
o	Silviculture for Energy Production	5,000
o	Powerline Right-of-Way Management	5,000
o	Composting by Competitive Bid	20,000
		52,000

Pilchuck Tree Farm Demonstration Project. Metro has initiated a cooperative program to apply sludge on 70 acres of forestland on the Pilchuck Tree Farm, Arlington, Washington (Figure 2-8), as part of the 1983 plan. The Pilchuck Tree Farm is owned and operated by the Pacific Denkmann Company.

The Pilchuck Tree Farm and Metro began the cooperative program in 1981. Since that time, Metro has undertaken a detailed site study of a 2,400-acre portion of the Pilchuck Tree Farm called the Armstrong Tract. Within that tract, Metro

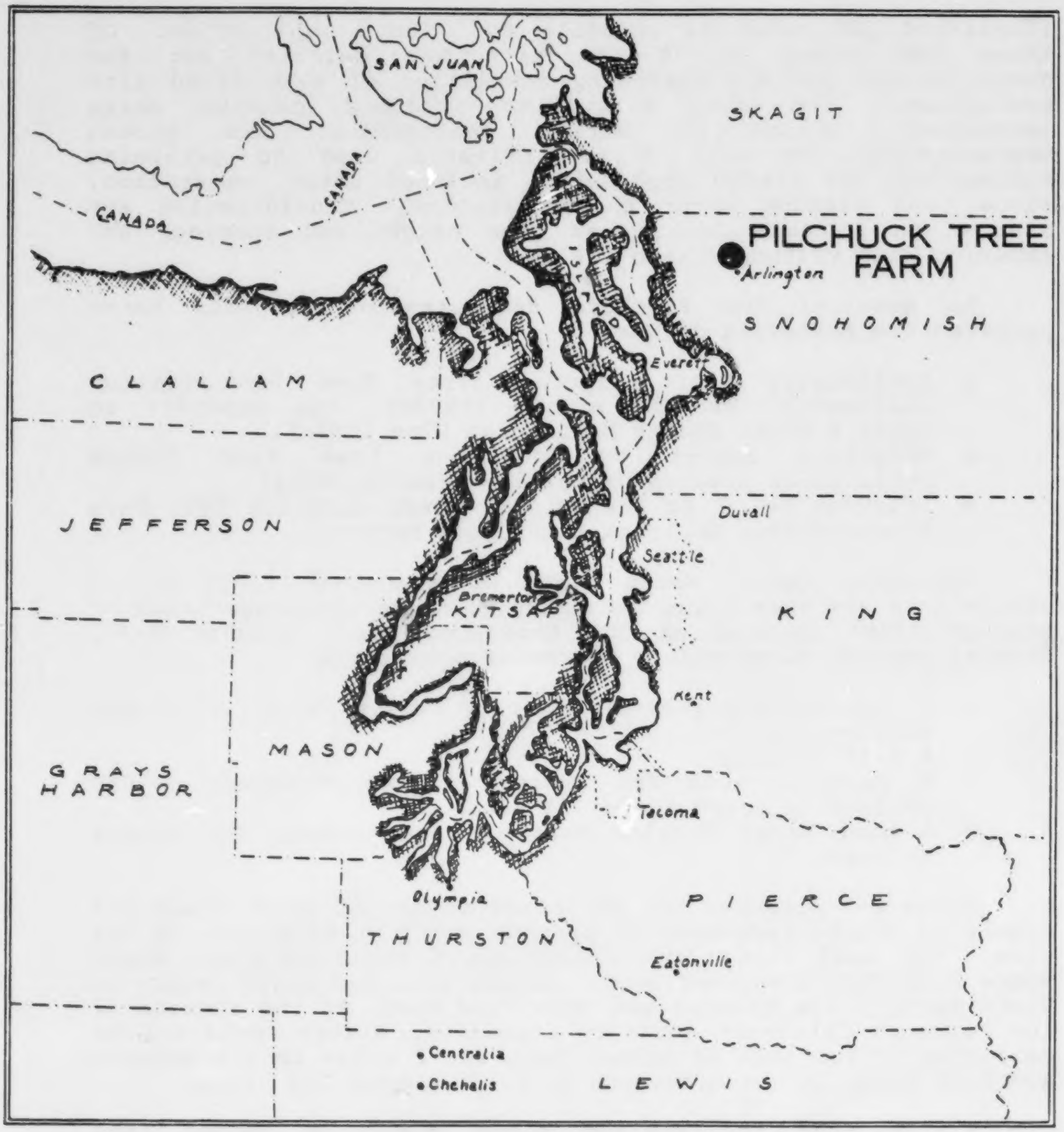

SAN JUAN
SKAGIT
CANADA
CANADA
PILCHUCK TREE FARM
Arlington
SNOHOMISH
Everett
CLALLAM
JEFFERSON
Duvall
Seattle
Bremerton
KITSAP
KING
Kent
MASON
GRAYS HARBOR
Tacoma
Olympia
PIERCE
THURSTON
Eatonville
Centralia
Chehalis
LEWIS

FIGURE 2-8
Location of the
Pilchuck Tree Farm, Arlington, Washington

identified 340 acres as suitable for sludge application. Of those 340 acres, a 70-acre site was selected for the demonstration project following completion of a detailed site evaluation. The site evaluation included on-site soils inspection, review of aerial photographs, and ground reconnaissance of each site. Criteria used to determine suitability for sludge application included soils, vegetation, slope, and surface water characteristics. Consideration was also given to such factors as tree height and spacing, and existing road systems (Metro 1983d).

As part of the Pilchuck demonstration project, Metro prepared the following documents:

- Preliminary Draft Pilchuck Tree Farm Demonstration Application Project Report (1983d), (an appendix to Metro's Draft Sludge Management Plan 1983a).
- Hydrology report for Pilchuck Tree Farm Sludge Application Site, November 1982 (Metro 1982a).
- Addendum No. 1 to Preliminary Draft Pilchuck Tree Farm Demonstration Application Project Report.

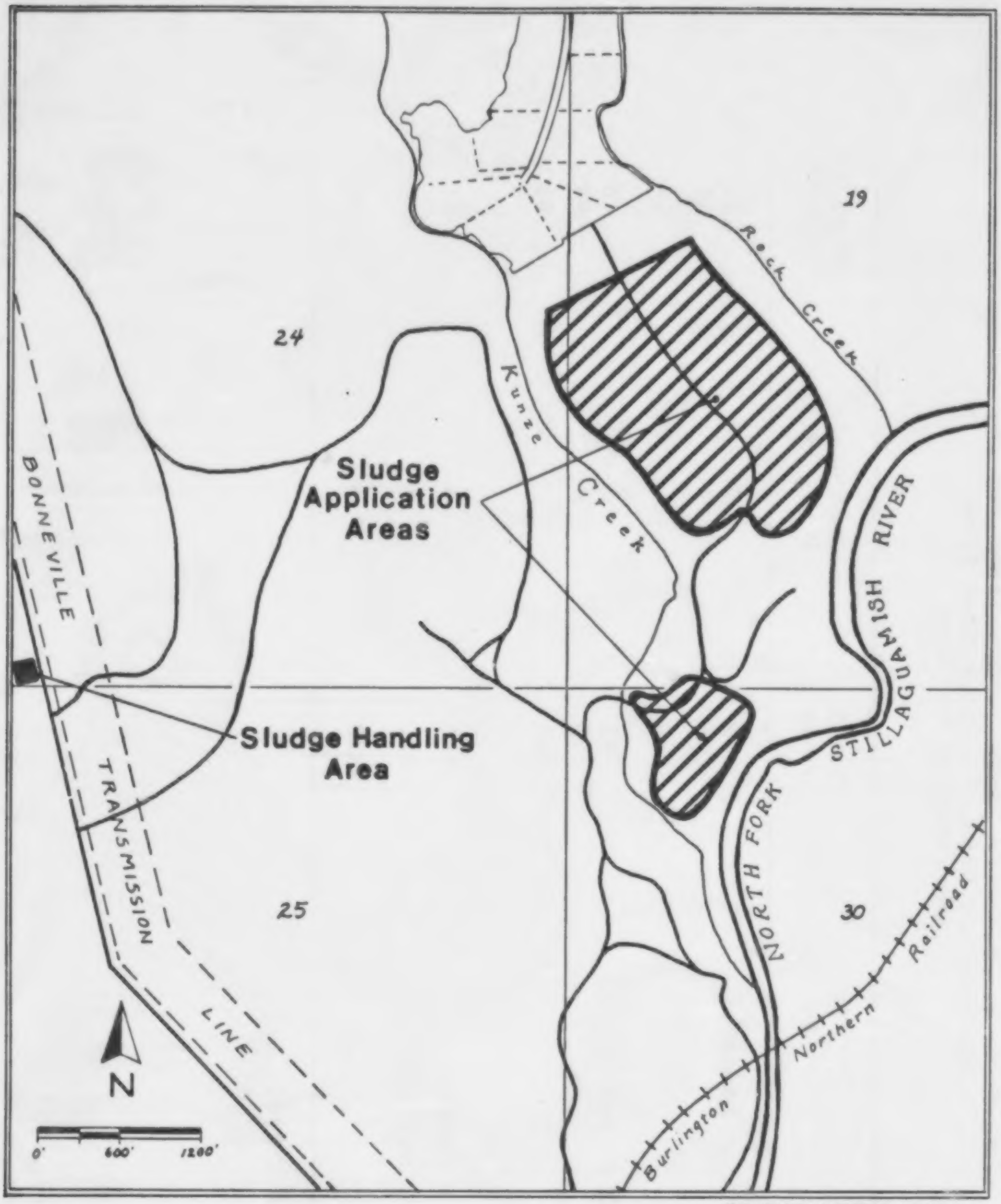
Operation Plan. Metro plans to transport 8,000 wt of sludge from the West Point Treatment Plant to a storage basin or storage tanks located on the Armstrong tract (Figure 2-9). Several storage alternatives are being considered:

- A one-million-gallon capacity basin with a 30-day storage capacity.
- A 0.25 MG basin.
- A reusable tank for storage of approximately 13,000 gallons (2 truck loads) of sludge.
- A haul truck trailer drop-off and pick-up for sludge storage.

Table 2-7 presents the projected number of truck loads and number of trucks necessary to provide 8,000 wt of sludge to the site. The haul route from Interstate 5 would be along State Route 9 and the Armstrong Road. Sludge vehicles would return to State Route 9 via Brakken and Grandview Road. At the request of the Pilchuck Citizens' Advisory Committee, sludge would not be delivered to the site on school days for 2 hours in the morning and 2.50 hours in the afternoon to avoid school bus hours.

Sludge from the storage basin would be pumped into all-terrain application vehicles which would apply sludge onto the 70-acre site using a remote-control powered, cannon-type spray mechanism. The spray mechanism would be capable of distributing sludge up to 150 feet from the vehicle.

Sludge application would occur only between October 15 and March 15. Sludge would be applied at a rate of 20 dry tons per acre (1-inch depth) over the site.


19
Rock Creek
24
Kunze Creek
Sludge Application Areas
NORTH FORK STILLAGUAMISH RIVER
BONNEVILLE TRANSMISSION LINE
Sludge Handling Area
25
30
Burlington Northern Railroad
N
0'
600'
1200'

SOURCE: METRO, 1982 d

FIGURE 2-9
Proposed Sludge Application Sites and Facilities, Pilchuck Tree Farm, Arlington, Washington

Table 2-7. Estimated Truck Loads, Trips Per Day and Hauling Days, Pilchuck Tree Farm Demonstration Project

Storage Alternative	Total Loads	Average/ Day	Days of Hauling
One-million-gallon basin	180	9	20
	185	4	46
	365		66
Small basin (0.25 mg)	45	9	5
	320	4	80
	365		85
Reusable tank			
o 18% solids content	365	4	91
o 13% solids content	520	5	104
Trailer	520	5	104

SOURCE: Metro 1983d.

Site Monitoring. Metro has defined a site monitoring plan to be carried out during and after sludge application. An intensive monitoring program would continue for 12 months following sludge application, with less frequent sampling to continue for 5 years after application.

Monitoring of the site would include:

- Water Quality - Water quality in test wells located adjacent to and within the application site would be monitored. Water quality testing would also be carried out at nearby Kunze and Rock Creeks and at springs down-slope of the application site.
- Forest Productivity - Measurements of growth rate of the forest would be coordinated by the Pilchuck Tree Farm management.
- Wildlife - University of Washington researchers would investigate the effects of sludge application on wildlife species. Monitoring would include determination of changes in species diversity and numbers, health of the wildlife, and effects of metals and other contaminants. Metro staff would also evaluate impacts on fish populations.

A more detailed discussion of the proposed demonstration project and impacts of that action is presented in Chapter 3 of the EIS.

Approach to EIS Evaluation of Alternatives

Chapter 3 of this EIS presents an impact analysis of Metro's long-range and near-term sludge management plans. Chapter 3 is divided into two separate impact analyses: an evaluation of long-range (20-year) plan, and an analysis of the proposed Pilchuck Tree Farm sludge demonstration project. The analysis of the sludge management plan consists of "generic" evaluations of soil improvement, silviculture, agricultural application and composting. The Pilchuck demonstration project impact analysis consists of detailed project-level evaluation. Chapter 3 of the EIS presents descriptions of the existing conditions of the planning area in general, and Pilchuck Tree Farm in particular. It also identifies mitigation measures to minimize adverse impacts.

Chapter 3

Environmental Setting and Impacts of Alternatives

- Impacts of Sludge Processing
- Impacts of Feasible Long-Range Alternatives
- Impacts of Metro's Preferred Long-Range Alternatives
- Impacts of Metro's Near-Term Plan
- Impact Analysis of the Pilchuck Tree Farm Demonstration Project

Chapter 3

ENVIRONMENTAL SETTING AND IMPACTS OF ALTERNATIVES

Introduction

This chapter includes impact analyses of: 1) sludge processing features common to all Metro long-range sludge management alternatives; 2) the long-range alternatives of agricultural application, composting, silvicultural application, and soil improvement; 3) Metro's preferred long-range program; 4) Metro's proposed near-term program; 5) the no-project alternative; and 6) the proposed near-term silvicultural application project at the Pilchuck Tree Farm.

Impacts of Sludge Processing

All of Metro's proposed project alternatives, as well as the preferred long-range and near-term plan alternatives, would require construction of sludge processing facilities at the Renton and West Point treatment plants. For all feasible alternatives considered, sludge thickening and dewatering equipment would be required at both plants, whereas additional anaerobic digestion capacity would be installed only at the Renton Treatment Plant. For the composting alternative, Taulman-Weiss composting tanks would be installed on-site at both Renton and West Point.

Renton Treatment Plant

EPA's Final EIS - Wastewater Management Plan for the Lake Washington/Green River Basins (1981a) included an impact analysis of construction and operation of proposed sludge handling facilities at the Renton Treatment Plant, and therefore, will not be discussed herein. The site evaluation, which included a cultural resources survey and impact evaluations, are hereby incorporated by reference into this EIS. Energy consumption for sludge processing, by alternative, is shown in Table 3-1.

Taulman-Weiss Tank Composters. Alternative 2A calls for installation of 7 bioreactor and 4 cure reactor tanks at the Renton Treatment Plant. These tanks would be installed on the existing treatment plant property on a portion of the property previously evaluated in the 1981 EIS (EPA 1981a; Hammond pers. comm.).

Table 3-1. Energy Production for the Various Project Alternatives

	Million BTUs Produced[1] (Year 2000)	
Alternative	West Point	Renton
Alternative 1		
Eastern Washington	88,620	21,154
Western Washington	121,488	57,010
Alternative 2A	127,575	60,424
Alternative 2B	122,759	61,122
Alternative 7A	115,014[2]-129,954[3]	53,275[2]- 66,099[3]
Alternative 7B	172,053 - 173,423	109,567 - 113,800
Alternative 7C	126,779 - 128,149	64,293 - 68,256
Alternative 7D	115,014 - 129,954	53,275 - 66,099
Alternative 8A	93,258 - 130,359	29,153 - 64,262
Alternative 8B	122,609	59,376

NOTES: [1] All alternatives would produce more energy than would be consumed.

[2] Assumes trucking maximum distance from treatment plants.

[3] Assumes trucking minimum distance from treatment plants.

SOURCE: Metro 1983b.

The in-vessel composting method would not adversely affect land uses, public health or aesthetics of the surrounding vicinity since this method would limit dust, odor, and unsightliness that could otherwise affect the area. The most significant impacts associated with tank composting at the Renton Treatment Plant would be energy consumption, air emissions from the compost facilities, and the increased truck traffic resulting from removal of composted sludge. Projected energy requirements for the Taulman-Weiss composting are included in the energy production estimate for Alternative 2A presented in Table 3-1.

After January 1988, on-site composting would result in increases in trucking traffic from the Renton Treatment Plant. Since sludge is currently not processed at the Renton Plant, increases in truck traffic would occur once sludge processing facilities are on-line regardless of which alternative is implemented. Table 3-2 presents the projected truck traffic from both the Renton and West Point plants to the year 2000.

West Point Treatment Plant

Under all of the project alternatives, few additional sludge processing facilities would be added at the West Point Treatment Plant; one additional sludge thickener and one additional Humboldt dewatering centrifuge would be installed and housed within existing structures at the plant (Uchida pers. comm.). Therefore, no impacts of any consequence are expected from additional West Point sludge processing.

Taulman-Weiss Tank Composters. Under Alternative 2A, 6 bioreactors and 2 cure reactors would be installed at the West Point Treatment Plant. Although no exact location for these tanks has been chosen, land is available on the eastern part of the treatment plant property (Uchida pers. comm.).

The construction and operation of the tank composters at West Point would not adversely affect land uses in the surrounding vicinity due to the enclosed nature of the facilities. Trucking from the plant would increase until 1988, at which time truck traffic would decrease due to start-up of sludge processing facilities at the Renton Treatment Plant (Table 3-2). Air emissions from the Taulman-Weiss system would be as previously described for the Renton Treatment Plant.

Impacts of Feasible Long-Range Alternatives

The following section of the EIS describes the existing environmental impacts and mitigation measures associated with sludge transportation, and with five broad uses of sludge-agricultural application, composting, landfill

Table 3-2. Projected Truck Traffic From the Renton and West Point Treatment Plants, 1980-2000

	Year					
	1980	1983	1985	1990	1995	2000
Renton Treatment Plant[1,2]						
Trucks/day	--	--	--	7	9	9
Trucks/year	--	--	--	2,555	3,285	3,285
West Point Treatment Plant[2]						
Trucks/day	7	9	13	8	8	9
Trucks/year	2,555	3,272	4,794	2,920	2,920	3,285

NOTES: [1] Assumes sludge processing on-line in January 1988.

[2] Assumes 50 percent of sludge volume each from West Point and Renton Treatment Plants after 1988.

application, silvicultural application, and soil improvement. Each of the 10 feasible long-range alternatives selected by Metro fall within one of these categories.

Impacts of No-Action

EPA procedures for implementing NEPA require that the impacts of a no-action alternative be examined in EISs. The no-action alternative for this EIS relates to two separate features of Metro planning effort: 1) the long-range and near-term plans, and 2) the proposed Pilchuck Tree Farm demonstration project. The analysis below pertains to no-action for the long-range and near-term plans. No-action for the Pilchuck project will be analyzed later in this chapter.

The purpose of Metro's sludge management plan and recommended program is to provide a framework for initiating sludge-utilization projects during the 20-year planning period. Metro's preferred long-range program does not define specific projects but instead indicates a series of goals and actions that Metro could take to manage sludge within the 20-year planning period.

No-action would essentially mean that Metro would continue with a year-by-year planning approach with no allowance for long-term commitments beyond 3-5 years to use of sludge for agricultural application, composting, silvicultural use or soil improvement. No-action would create a situation whereby Metro might not have adequate flexibility and contingencies in the event established sludge application sites could no longer be utilized.

Metro is also faced with a problem of not being able to fully utilize the King County Cedar Hills Regional Landfill. During the past 3 years, approximately 49 percent of Metro sludge was applied at that site, however, indications are that only 2,000 dry tons, or less than 6 percent of the 1983 projected quantity of sludge, can be utilized at that site during the current year (Machno pers. comm.).

The completion of an approved sludge management plan is a requisite for DOE approval of plans and specifications for solids handling facilities at the Renton Treatment Plant. No-action would mean that solids handling facilities could not be designed or constructed, and that Renton sludge would continue to be pumped to the West Point Treatment Plant for processing and disposal.

Additionally, the NPDES permits for the West Point and Renton treatment plants require that facilities plans (of which sludge management is a part) be completed for both plants.

Impacts of Sludge Transportation

All feasible sludge management alternatives will require transporting sludge, in either anaerobic or composted form, from the Renton and West Point treatment plants. Table 3-2 indicates that the number of trucks leaving the two treatment plants will increase from 9 per day in 1983 to 18 per day in the year 2000.

Table 3-3 presents the projected annual fuel consumption for sludge trucking for each of the feasible alternatives.

Under all alternatives (except 2A - tank composting), sludge would be transported from the treatment plants in 30 cubic-yard leakproof, open top dump trucks or semi-wagon combination trucks with a capacity of 37.5 cubic yards of sludge. Because of the thick consistency of sludge at 18 percent solids, spills from the open-topped trucks are unlikely. The dump trucks are of leakproof design to prevent leakage around the rear dump gates.

The haul route from the West Point Treatment Plant would be along the present haul route through Discovery Park to Interstate 5, and then either north or south to the destination. The haul route from the Renton Treatment Plant would be along Monster Road to the West Valley Highway, with access to either Interstate 5 or Interstate 405. The small increase in truck traffic caused by sludge transportation will not affect the capacities of these road ways.

Because specific reuse in disposal sites have not been identified in Metro's long-range planning, specific transportation impacts at these sites cannot be evaluated here, but would be evaluated in project-specific environmental reviews.

Table 3-4 presents the air emissions likely to result from sludge hauling for each of the feasible long-term alternatives. These emissions are small compared to regional mobile source emissions.

Agricultural Application

Description of Existing Environment. Metro (1983) has defined agricultural lands located from 45-190 miles from the Renton and West Point treatment plants as potential agricultural sludge application sites. Agricultural lands within this range may be divided into three physiographic provinces: Puget Sound Trough, Okanogan Highlands, and Columbia Plateau.

The Puget Sound Trough encompasses those areas between the Cascade and Olympic mountains and is characterized by a mild, wet climate, with most of the precipitation occurring between November and May. The northern portion of this region receives

Table 3-3. Projected Annual Fuel Consumption for Sludge Trucking for Each Feasible Alternative (gal/yr)

Alternative	1983	1990	2000
1 - Agricultural Application	65,700 - 277,400	109,500 - 462,455	131,400 - 554,800
2 - Composting	14,600 - 43,800	24,455 - 73,000	29,200 - 87,600
7 - Silvicultural Application			
7A, 7D	43,800 - 138,700	73,000 - 231,045	87,600 - 277,400
7B, 7C	29,200 - 65,700	48,545 - 109,500	58,400 - 131,400
8 - Soil Improvement			
8A	14,600 - 270,100	24,455 - 450,045	29,200 - 540,200
8B	109,500 - 138,700	182,500 - 231,045	219,000 - 277,400
Pilchuck	102,200	170,455	204,400

Table 3-4. Air Emissions From Trucking for Each Feasible Alternative

	Emissions (lbs/day)					
	HC		CO		NO_x	
Alternative	1983	2000	1983	2000	1983	2000
1 - Agricultural Application	5.3-16.5	10.7-33.0	16.4-50.5	32.7-101.0	23.9-189.4	47.8-378.8
2 - Composting	1.0-3.0	1.9-6.1	2.7-9.3	5.4-18.5	8.3-29.7	16.6-59.3
7 - Silvicultural Application						
-7A,7D	2.9-9.6	5.8-19.1	8.1-28.2	16.2-56.3	25.0-87.6	49.9-175.1
-7B,7C	4.4	8.8	12.13	24.26	37.45	74.90
8 - Soil Improvement						
-8A	1.5-15.0	3.1-29.9	4.7-45.8	9.5-91.5	9.6-179.8	19.1-359.6
-8B (WIDCO)	7.6-9.5	15.1-18.9	23.2-29.0	46.3-57.9	74.1-94.0	148.3-187.9
Pilchuck Demonstration Project	6.4	---	19.8	---	70.5	---

SOURCE: EPA 1981b; Metro 1983a.

40-80 inches of precipitation a year and has a growing season of 150-200 days. Agricultural soils in this northern portion are concentrated in the deltas and valleys of Skagit and Nooksack Rivers and were formed on a mixture of coarse glacial deposits and finer-textured alluvial (river-deposited) material. Soils are high in organic matter with CEC ranging from 10-25 meq/100 grams, and pH's generally below 6.5 except where extensive liming has occurred. Approximately 250,000 acres of agricultural land exist in the northern Puget Sound Trough, with hay, alfalfa, and dairy being the major uses. Other crops include various grains, flowers, and vegetables.

The climate of the southern Puget Sound Trough (south of Seattle) is slightly milder than that of the northern Puget Sound Trough, with the growing season often exceeding 200 days. Soils in this southern region were not greatly influenced by glacial activity, but have developed on volcanic or sedimentary bedrock and alluvial deposits. Soils are generally fine-textured, with low pH's (below 6.5) and variable CECs. Major crops include silage, barley, corn, and peas, with much land devoted to dairy production. Over 300,000 acres of agricultural land exist in the southern Puget Sound Trough.

The Okanogan Highlands encompasses those areas east of the Cascades and north of the Columbia River. This region is drier than areas west of the Cascades, with an average annual precipitation of about 30 inches and a growing season of about 120 days. Soils are often thin, having been formed on glacial deposits and volcanic outcrops. Soil pH is generally above 6.5, and the CEC ranges from below 5 to near 20 meq/100 grams, except in areas where soil conditioners have been used. Major crops include apples, pears, wheat, and barley.

The Columbia Plateau includes the rolling hills of south central Washington. This area is slightly drier and warmer than the Okanogan Highlands, receiving about 15 inches of precipitation and having a growing season of 130-180 days. Soils are underlain by volcanic and sedimentary bedrock. Pockets of saline and loess (wind deposited) soils exist in the eastern portion of the area. Soil pH is usually high (above 7.0) and CECs range from 10-30 meq/100 grams. Over one million acres are devoted to agriculture and range, with livestock, silage, wheat, barley, apples, and pears as the major crops.

Assessment of Impacts. Alternative 1 consists of applying 3.1 dry tons of sludge per acre on agricultural land to grow nonhuman food chain crops (i.e., crops to produce animal feed). In western Washington sludge would be stored in a central 36 MG capacity lagoon and applied 8 months of the year. In eastern Washington, sludge would be stored in 9 lagoons ranging from 3.3 to 4.2 MG each. Sludge would be applied using a subsurface injector system.

Subsurface Injection System -- Many potentially adverse impacts would be avoided with the use of the subsurface injection system. Because sludge would be immediately incorporated into the soil, the likelihood of surface water contamination would be minimized. Subsurface injection would also minimize odors and allow for greater capture of nitrogen (normally lost by volatilization when sludge is applied on the surface).

Agricultural Soils and Crops -- A number of physical and chemical properties of agricultural soils would be changed as a result of sludge application. Although the characteristics of soil types vary widely in western and eastern Washington, a number of potential impacts can be predicted.

In 1979, the EPA set forth Criteria for Classification of Solid Waste Disposal Facilities and Practices; Final, Interim Final and Proposed Regulations (40 CFR Part 257). In those regulations EPA recognized that " . . . land application of parks and forests and reclamation of poor or damaged terrain is a desirable land management technique . . .," and that "application of solid waste to agricultural lands may also be an environmentally acceptable method of disposal."

EPA has established cadmium to be an important factor when sludge is applied to agricultural land. During development of the regulations, EPA examined a wide range of available scientific data associated with health effects of cadmium, maximum cumulative loadings of cadmium assuming a variety of "diet scenarios", annual cadmium application limits and cadmium allowances for growing animal feed. Appendix G of this EIS includes the entire text of the disposal regulations (40 CFR Part 257).

EPA (40 CFR Part 257 1979c) has determined that the maintenance of a soil/sludge pH of 6.5 is a critical factor for land used for production for either foodchain crops or crops for animal feed. Soils in western Washington typically have pH ranging from 4.5-6.0, and must therefore be limed to adjust the soil pH to the necessary 6.5 level. Metro proposes to apply lime at a rate of 3 tons per acre every 3 years on agricultural soils in western Washington to achieve this pH.

EPA (40 CFR Part 257 1979c) has also determined the allowable annual cadmium loading rate per acre for production of leafy vegetable and root crops (0.5 kg/ha or 0.45 lb/acre) and for other food chain crops (2.0 kg/ha until June 30, 1984; 1.25 kg/ha July 1, 1984 to December 31, 1986; 0.5 kg/ha beginning January 1, 1987). No maximum annual cadmium loading rates have been established for crops to produce animal feed. The basis for these allowable loading rates is presented in Appendix G of this EIS.

Assuming Metro's proposed annual sludge application rate of 3.1 dry tons/acre, the annual cadmium loading rate would be 0.32 kg/ha - well below the 0.5 kg/ha for the most restrictive use, which is crops (leafy vegetables and root crops). At the rate of 0.32 kg/ha/year, sludge could be applied for over 60 years to agricultural soils having a CEC greater than 15 meq/100 kg before the allowable cumulative cadmium application rate of 20 kg/ha was reached (see Appendix B for a discussion of the importance of CEC). On the most restrictive soil (CEC less than 5 meq/100 kg), sludge could be applied for 15 years before the cumulative cadmium application rate of 5 kg/ha was reached (DOE 1982a).

An application rate of 3.1 dry tons per acre per year would supply the equivalent of 98.0 pounds of nitrogen, considerably less than the annual per acre nitrogen requirement for silage corn (185 pounds per acre) or orchard grass (300 pounds per acre). Because the annual nitrogen requirement for crop growth would be greater than the amount applied in sludge, the likelihood of nitrate leaching to groundwater would be very low. Nearly 6 tons of sludge per acre would be needed to meet annual nitrogen requirements for corn, and 9.5 tons per acre would be needed to meet nitrogen requirements for orchard grass.

Based on EPA regulations (40 CFR Part 257 1979c) the low application rate proposed by Metro would allow the land to be used in the future for even the most restrictive agricultural use (food chain crops - leafy vegetables and root crops) so long as the cumulative concentrations of cadmium would not exceed 20 kg/ha for a soil with a CEC of greater than 15 meq/100 kg, or 5 kg/ha for a soil with a CEC of less than 5 meq/100 kg.

The State of Washington is in the process of revising the Regulations Relating to Minimum Functional Standards for Solid Waste Handling (Chapter 173-301 WAC) to be compatible with 40 CFR Part 257 and specifically to address application of wastes to land used for the production of food chain crops (DOE 1980).

The impacts of sludge application to agricultural land have been extensively studied since the early 1970s. EPA (1976a) has indicated that proper site management is the key to minimizing adverse impacts caused by sludge application. Close attention must be paid to application rates, soil pH, and the types of crops selected. In 1977, Washington State University conducted a study of sludge application to agricultural land using 10, 20, and 40 dry tons of Metro sludge per acre. Comparisons were made of heavy metal concentrations in limed and unlimed soils, and silage corn and rye. Nitrate movements through the soil profile and total and fecal coliform levels were measured. In general, metal uptake by plant tissues was increased by sludge applications, with rye being less effective than corn in taking up metals. Fecal coliform was reduced to less than 1 percent of initial value in approximately 6 months.

Because Metro does not plan on growing crops for direct human consumption, sludge applied to the agricultural land would need only to be treated by a "Process to Significantly Reduce Pathogens" (e.g., anaerobic digestion). In addition, public access to the application site must be controlled for 12 months, and animal grazing must be prevented for at least 1 month (EPA 40 CFR Part 257 1979c).

As part of any agricultural application program, Metro has defined the following site monitoring features:

- One soil sample per net 200 acres of sludge-applied land with sampling every 2 years for a 5-year period following last application.
- One surface water sample per 250 gross acres with samples taken monthly for 2 years following last application.
- One shallow groundwater well per 20 net acres and one deep well per 300 net acres with monthly sampling for 1 year (shallow well) and 5 years (deep well) following last sludge application.

Application of Metro sludge to agricultural lands would result in increased trace metals concentrations in plants, increases in heavy metals within the soils, and elevated coliform and pathogenic organism levels. However, environmental impacts of these sludge constituents can be minimized by proper site management and implementation of the mitigation measures described below.

Mitigation Measures. The impacts of sludge application to agricultural land can be minimized by following EPA regulations and guidelines and Best Management Practices developed by DOE (1982a). EPA and DOE regulations and guidelines should be used in agricultural application site selection, since they reflect current knowledge of the impacts of agricultural land application.

Prior to application of any sludge, Metro proposes to:

1. Develop and finalize evaluation criteria to determine site acceptability.
2. Develop an inventory of possible sludge agricultural application sites.
3. Evaluate and prioritize sites based on DOE's BMPs.
4. Initiate a detailed site selection process.

Because specific agricultural application sites have not been identified in Metro's long-range planning, subsequent site-specific environmental evaluations would be necessary to evaluate site-specific impacts if agricultural application is implemented.

Composting

Description of Existing Environment. The composting alternatives considered by Metro would require location of facilities at either the Renton and West Point treatment plants or in the Kent Valley industrial area. The existing environment of the Renton Treatment Plant vicinity has been reviewed in a previous 1981 EPA EIS.

The West Point Treatment Plant is located on approximately 24 acres in north Seattle on a flat, triangular piece of land between Discovery Park on the east and Puget Sound on the west. East of Discovery Park are a mixture of single and multifamily, commercial, and manufacturing uses.

The Kent Valley industrial area includes heavy industrial land uses, railroad lines, and scattered residential dwelling units. Sludge composting is presently carried out in the industrial area by GroCo, a subsidiary of the Sawdust Supply Company. The GroCo facility is located at the corner of 76th Avenue South and South 202nd Street, 3 miles north of downtown Kent.

Assessment of Impacts. The impacts associated with Alternative 2A (Taulman-Weiss composting) at the West Point and Renton treatment plants were previously discussed under Impacts of Sludge Processing. The following analysis relates to impacts associated with composting operations of Alternative 2B and distribution of the composted product.

Air Emissions from Trucking -- Under Alternative 2B, anaerobically-digested sludge (18 percent solids) would be hauled to a composting site in the Kent Valley Industrial Park, and either temporarily stored or immediately mixed with a bulking agent. The air emissions from trucking are presented in Table 3-3.

Land Use -- Development of a 24-acre composting facility would not appreciably affect land uses in the area since composting would be compatible with heavy industrial/commercial uses of the area. If residential areas were located near the site, impacts from the composting facility could result. In particular, noise, light, and glare and odors are likely to result from the composting activities.

Surface and Groundwater -- Ground and surface water could be potentially affected by runoff from the compost site. However, complete paving of the site and development of a runoff collection system would eliminate the likelihood of significant impacts.

Occupational Health and Safety -- Dust and fungal spores may be generated by composting operations, and particulate matter may drift off-site during high wind conditions. Public health hazards associated with composting involve four groups of pathogens in sewage sludge: viruses, bacteria, cysts of protozoans, and ova of helminths. The survival of these pathogens depends upon the treatment of sludge prior to composting. In general, anaerobic digestion has been shown to reduce the concentration of detectable viruses, bacteria, and protozoa cysts by 85-95 percent. Helminth ova, however, are resistant to anaerobic digestion (EPA 1979).

Composting is a thermophilic (high temperature) aerobic decomposition process. The heat generated during composting can both reduce and increase microorganisms, depending upon the species type. Organisms such as salmonellae, total and fecal coliforms and fecal streptococci are significantly reduced by composting while thermophilic microorganisms such as actinomycetes, murcorales, and Aspergillus fumigatus proliferate as a result of the high temperatures (EPA 1981c).

A major public health concern for compost workers in general is exposure to microbial dusts, when the compost piles are turned to maintain aerobic conditions. Direct bodily contact with sludge through either the initial mixing of compost or the pile turning can expose workers to pathogens.

Compost workers' exposure to aerosols generated at a composting site would be small compared to exposure at a wastewater treatment plant. The clouds of moisture that emerge from compost piles result from water leaving the sludge matrix as gas and condensing into visible droplets. This moisture should be essentially free of microorganisms and salts. Very little if any information exists on aerosol transport from composting sites (Burge and Millner in Bitton et al. 1980).

The potential long-term health effects on compost workers exposed to a variety of fungal and bacterial pathogens and toxins of microbial origin are not well understood.

Public Health -- The ultimate use of the composted product has not been established by Metro, and a requisite for implementation of this alternative would be to determine the marketability of a composted sludge product in the Seattle area. DOE (1982b) and EPA have identified static aerated pile composting as a "Process to Further Reduce Pathogens" (DOE 1982b), a requirement if sludge is likely to be used to grow crops for direct human consumption.

Because trace metal concentrations are reduced by composting sludge (see Table 3-5), greater flexibility as to the ultimate use of the compost is possible. The concentration of trace metals, particularly cadmium, would need to be determined to establish allowable uses for the compost.

Because a specific composting proposal has not been identified in Metro's long-range planning, subsequent site-specific environmental evaluations would be necessary to evaluate site-specific impacts if composting is implemented.

Table 3-5. Nutrient and Metal Contents of Municipal Sludge and Compost. The Sludge was a 20% Solids Sludge from Seattle. The Compost was a 3:1 Sawdust:Sludge Mixture, Composted for 6 Months.

Nutrient or Metal	Sludge	Compost	Ratio of Elements Compost:Sludge
Nutrients (%)			
Nitrogen	2.30	0.71	0.31
Phosphorus	1.50	0.51	0.34
Potassium	0.16	0.09	0.56
Calcium	1.40	0.47	0.34
Magnesium	0.29	0.09	0.31
Heavy Metals (ppm)			
Zinc	2,000	490	.24
Copper	900	230	.25
Lead	470	220	.46
Nickel	170	85	.50
Cadmium	40	14	.35

SOURCE: Metro n.d.

Mitigation Measures. Any composting site selected should be designed with impervious surfaces and a runoff collection system connected to the municipal sewer. Consideration should be given to designing the site to minimize light, glare, and noise if sensitive receptors are in the vicinity.

Since the exposure of workers to composting sludge is of concern, the following mitigation measures should be considered:

- Use of respirators or breathing masks in any enclosed dusty areas or high-spore concentration areas.
- Sprinkling of site to reduce dust.
- Use of preemployment health histories to screen out employees who would be at some risk from aspergillus inhalation.
- Distribution of preemployment health safety information relevant to the compost site environment.
- Use of enclosed cabs on composting vehicles.

DOE (1982a) has established BMP for the processing and use of composted sludge. EPA is also in the process of drafting regulations regarding the use of compost products. Future regulations may restrict the distribution of composted sludge if heavy metal concentrations are too high for gardens and foodchain use. The ultimate use of composted sludge would conform with these future regulations.

The State of Washington has established Regulations Relating to Minimum Functional Standards for Solid Waste Handling (Chapter 173-301 WAC) which include some provisions for composting (WAC 173-301-401 and WAC 173-301-402). Relevant portions of those regulations state the following:

- "Materials resulting from composting and offered for use by others shall contain no pathogenic organisms, shall not reheat upon standing, shall be innocuous . . ."
- "Byproducts removed during processing shall be handled and disposed of in a sanitary and nuisance-free manner."

To ensure that composting is properly accomplished, temperature monitoring should be continually carried out during the process. EPA criteria (44 CFR Part 179) indicate that aerated pile composting must maintain temperatures of 131°F (55°C) for at least 3 days to ensure that pathogens are further reduced.

DOE (1982a) recommends that bulking materials be analyzed to ensure suitability for mixing with sludge. The compost product should also be monitored to determine pH, salinity, and nitrogen, phosphorous, PCB, and heavy metals concentrations.

Metro should initiate a study to define the potential users of a composted product and to determine a likely market in the event regulations regarding use of compost become more restrictive.

Silvicultural Application

Metro (1983a) has identified cost-effective silvicultural sites in Washington as being between 30 and 95 miles from Metro's treatment plants. Counties within this radius include all or part of Grays Harbor, King, Kitsap, Kittitas, Mason, Pierce, Skagit, Snohomish, and Thurston Counties.

Metro (1983a) has recommended four alternatives for sludge application to silvicultural sites:

Alternative 7A - Public or privately-owned forestlands with a Metro-owned demonstration site.

Alternative 7B - Metro-owned poplar growing forestlands.

Alternative 7C - Metro-owned multiple use forestlands.

Alternative 7D - Public and privately-owned forestlands with a Metro-owned back-up site.

Description of Existing Environment

Geology and Soils -- The majority of lands that might be considered for silvicultural use of sludge consist of areas of compacted glacial till (a dense mixture of gravel, sand, and silt) underlain by sedimentary bedrock. A coarse, excessively drained mixture of gravel, sand, and silt known as recessional outwash is found on top of the denser glacial till.

Surface formations vary widely, but areas in the lowlands are likely to have glacial till, glacial outwash or recent alluvial deposits (loosely arranged water-deposited material) at the surface. Soils have evolved through the interactions of parent material, time, climate, topography, and biota.

A large percentage of western Washington soils such as the Alderwood series have evolved on glacial till. Soils developed on glacial outwash are also very common. These soils, which include the Everett and Indianola series, are usually very coarse and have extremely rapid infiltration rates and permeabilities throughout the profile. Soils developed on alluvial deposits are less common; although these soils vary widely, they are often poorly drained and found on low-lying, nearly level terrain.

Silviculture -- The forests where sludge could be applied are quite varied, depending on climate, soils, and distinctive characteristics. The areas considered for sludge application can be categorized into vegetative zones according to their dominant species.

Most forests where sludge could be applied are classified in the western hemlock zone, which starts near sea level and extends upward to about the 2,000-foot level.

Because this zone is readily accessible, most of the area has been logged at least once. The most common species to occupy logged sites is Douglas-fir. Unlike hemlock, this species grows readily in open areas and has become the most common species in the area. Once established, the stands are often thinned and fertilized before the final harvest.

Red alder is a common species in wet areas and in riparian sites in western Washington. Western red cedar often develop beneath alder and may eventually dominate moist sites. Four species, Douglas-fir, hemlock, alder, and cedar, constitute the majority of trees in the western hemlock zone. Scattered patches of Sitka spruce, big leaf maple, and western white pine also exist throughout the zone.

Regions above 2,000 feet constitute the silver fir zone. This area is wetter and cooler than the adjacent western hemlock zone. In this zone, open sites are first colonized by Douglas-fir or noble fir, giving way to silver fir and western hemlock once canopy closure has occurred.

Surface Water -- The water resources of forest areas where sludge may be applied include a multitude of rivers, streams, lakes, springs, and other water bodies. Outside of the major urban areas, surface water quality is excellent in most cases. Surface water supports a variety of beneficial uses such as domestic and stock water supplies such as irrigation, recreation; fish reproduction, rearing and harvesting; wildlife habitat; power generation; and industrial use (DOE 1978). The 30-95 mile radius from Seattle covers approximately 25 DOE Water Resource Inventory areas which include a variety of surface water bodies of Class AA (extraordinary), Class A (excellent), Class B (good), and Class C (fair) (DOE 1977).

Groundwater -- The groundwater resources in the Puget Sound area are plentiful and multifaceted. In general, recharge occurs over the entire area, with water percolating through the soil to the underlying water table. This groundwater then continues to flow through the soil to a discharge point such as a spring, river, or the Puget Sound. Due to the geological history of the Puget Sound area, several aquifers (soil layers which can bear groundwater) have been created, one on top of the other, over much of the area. These aquifers are normally separated from each other by less permeable strata. Water percolating from the surface will recharge the uppermost aquifer, which is generally perched above the regional watertable.

Downward leakage from the perched aquifer generally recharges the underlying regional aquifer, which in turn may recharge underlying confined aquifers, being dependent upon the head differential between aquifers and the permeability of the confining strata.

Several groundwater and water resource studies have been conducted which include portions of the study area (Luzier 1969). Site-specific groundwater characteristics should be investigated during project design due to the varying nature of aquifers and groundwater.

Groundwater quality is good in most cases but can vary considerably among aquifers and within aquifers (Luzier 1969). Poor groundwater quality, such as high salinity or high NO_3 or high mineral concentration, can occur naturally due to the location of vegetation and soil characteristics of the aquifer. Anthropogenic degradation of groundwater quality can also occur due to land use practices and usage of the aquifers.

Common groundwater uses in the Puget Sound area are water supply, irrigation, and industrial supply. Groundwater also serves to maintain stream flow and local springs.

Wildlife -- The forest areas support a tremendous variety of vertebrate and invertebrate terrestrial and aquatic wildlife. Northwestern coniferous forests are a patchwork of vegetative cover types created by natural processes or man's activities, which provide for a diversity of wildlife species. Many areas support rare, endangered or threatened animal and plant species, and special biological areas identified by the USFWS, the Washington Department of Game, and the Nature Conservancy's Natural Heritage Program. Many counties also have identified sensitive or critical areas such as wetlands or areas particularly important to the maintenance of wildlife species (USFWS 1981).

Land Use -- Existing land uses within a 45-95 mile radius from Seattle consist of a variety of urban, rural, agriculture, and forestry uses. In general, urban areas are concentrated close to Puget Sound and along Interstate 5 and 405. An urban-rural fringe containing a range of uses from suburban to rural lies between the urban areas along Puget Sound and the rural areas near the Cascade and Olympic Mountains. Agricultural activities occur in the bottom lands and floodplains of the area's major rivers. Much of the land in the Cascade and Olympic Mountain ranges is used for forests.

Land use planning and control in the area is the responsibility of the counties and local municipalities, with planning coordination provided by regional planning agencies. Major regulations and policies covering land uses are found in comprehensive county and municipal plans, zoning ordinances, subdivision ordinances, shoreline master programs, subarea plans, and comprehensive water and sewer plans.

Assessment of Impacts. The following discussion of impacts associated with sludge application on forestlands provides a broad overview of potential impacts in the Puget Sound area. A detailed impact analysis of the Pilchuck demonstration project follows.

Geology and Soils -- Geologic features are important considerations for sludge application because they control the movement of groundwater and influence soil properties. According to the DOE (1982a), areas considered for sludge application should not have parent material which is excessively drained. In areas where bedrock is present, it should be at least 3 or 4 feet below the soil surface. Bedrock should be free from coarse conducting layers or conduits. These guidelines would eliminate the following land areas as potential sludge application sites:

- o Mountain regions with shallow soils.
- o Areas with excessively drained parent materials, such as those underlain by coarse glacial outwash.

Construction activities associated with sludge application to forest sites would include sludge basin excavation and construction of skid roads to gain access to the site. These activities would have no major impact on the geology of forest sites in western Washington.

Sludge should not be applied to soils that possess high antecedent heavy metal or nitrogen levels due to the possible contamination of groundwater if it is used for water supply.

The DOE recommends that the average surface slope of forested land receiving sludge not exceed 20-30 percent (DOE 1982a). Slopes up to 40 percent may be utilized if the slope length is short.

These recommendations greatly limit the amount of land suitable for sludge application. Most of the mountain areas are too steep or have thin soils. Many of the low-lying areas in the Puget Sound basin possess soils with fine surface textures or water tables close to the surface.

The suitability of a soil for sludge application depends on the physical, chemical, and mineralogical properties of the soil. Physical properties may be the most important of these.

Soil texture determines the rate of soil water movement and sludge decomposition. Coarse surface soils are desirable for sludge application because of their high infiltration rates and limited potential for surface runoff and erosion. A finer soil texture below the surface layer is desirable to prevent rapid movement of infiltrating water to the groundwater. Clay soils should be avoided to decrease the possibility of surface runoff. Ideally, soils should be deep (greater than 3 feet) and possess an impermeable layer at the 3- to 5-foot depth (DOE 1982a). The water table should be below 5 feet or be absent, and soil pH should be above 6.5 to limit the movement of heavy metals into the groundwater (DOE 1982a). Soils which contain significant amounts of organic matter in their surface layers will also help arrest heavy metal movement (Appendix B).

Lagoon and skid road construction impacts may include soil compaction, top soil removal, and increased erosion. These impacts are likely to be most significant on soils that are shallow, organic, fine textured, located on steep slopes, or possess impermeable layers close to the surface.

Soil compaction would occur wherever vehicles move across undisturbed soil. Compaction can result in reduced infiltration, increased runoff, and a reduced availability of oxygen to plant roots. Wet soils or soils with a high clay content are especially vulnerable to compaction. Topsoil removal for road construction may severely decrease future site productivity; this impact would be most significant on sites with gravelly soils which have a limited amount of organic material.

Some soil erosion can be expected because of the exposure of bare soil during construction. Because potential sludge application sites are generally not steep, soil loss should not be widespread. Soils with coarse upper horizons underlain by layers with restricted drainage are most susceptible to erosion.

Silviculture -- Forest species vary widely in their response to sludge application. Variables controlling species response include stand age, sludge application rate and timing, and site productivity.

Table 3-6 shows the overall suitability of species for sludge application. High mortality of hemlock and red cedar seedlings has been observed on sludge-treated sites (Henry and Cole 1983). Metro (1982) has recommended that sludge not be applied to stands under 4 feet in height or those within 10 years of harvest. Although older stands (50 + years) may react favorably to sludge application, recent research suggests that the greatest growth responses may be realized by applying sludge to stands between the ages of 5 and 30 years growing on poorer quality sites (Henry and Cole 1983). Sludge application to species which fix nitrogen, such as red alder, is not recommended due to the potential for increased nitrate leaching (DOE 1982a). This would be a particularly important consideration if the site is used as a drinking water supply.

In summary, silvicultural application of sludge is subject to certain constraints based on geology, soils, topography, and tree species and age. Other constraints concern the maintenance of buffer zones around water bodies and dwellings. Due to constraints, not all forestland is appropriate for silvicultural sludge application.

King County, for example, contains approximately 867,000 acres of forestland. Approximately 17 percent of this is Wilderness Area, which by law is not available for sludge application (U. S. Department of Agriculture 1978). An additional 29 percent is located within municipal watersheds.

Table 3-6. Species Suitability Classes

Site Condition	Species Selection		
	Best	Adequate	Unsuitable
Recently cleared sites	Cottonwood Poplar Douglas-fir Sitka spruce	Pines	Western hemlock Redcedar Red alder
Young plantations	"	Pines	Red alder
Existing forests	Most conifers	Pines	Red alder and most other deciduous species

SOURCE: DOE 1982a

Assuming Wilderness Areas and watersheds are excluded from consideration, approximately 477,000 acres remain as potential silvicultural disposal sites. The exact portion of this land not suitable for sludge application due to such environmental constraints as soils and slopes, is not known. Metro, however, has estimated that for the silvicultural sludge application alternative requiring public or private land (Alternative A), 70 percent of the area considered would be unsuitable due to buffer zones, slopes, sensitive soils, and roads (Metro 1983a). Based on this assumption, approximately 143,000 acres would be potentially suitable for use under Alternative 7A. This figure is considerably larger than the 41,100 acres Metro projects it may need to accommodate 100 percent of the sludge produced from 1990-2000 using land owned by agencies or companies in the timber management business. Only approximately 20,000 acres would be needed if 2 inches of sludge were applied per acre rather than 1 inch.

Construction-related impacts on the silvicultural resource would be caused by removal of land from forest production. These impacts would vary, depending on the quantity of skid roads to be constructed, the size of the lagoon and surrounding facilities, and the quality of stands that would have to be removed.

Surface Water -- Specific impacts of a silvicultural application of sludge on surface water are dependent on the site location. A complete investigation is necessary for each site before application occurs. This investigation should include the determination of the following surface water characteristics:

- location of streams, tributaries, and lakes
- location of wetlands and flood plains
- hydrological data
- water quality data
- existing and possible future uses

Other factors which also are important for a complete surface water impact assessment include: topography, groundwater flow and quality, and soil characteristics.

Types of possible impacts on surface water are:

- nutrient enrichment
- decrease in water quality
- contamination of water supply
- decrease in quality of stream habitat

Nitrogen and phosphorous are the most common limiting nutrients in a water body. Both are added to the forest environment during a sludge application and, if allowed to a water body, may result in some of the above-listed impacts. Nitrogen is of special concern due to the ease at which nitrate travels through the forest environment. Other sludge constituents, such as heavy metals and pathogens, may also result in the above-listed impacts if allowed to enter the surface waters.

Groundwater -- Groundwater impacts would result if sludge constituents were to migrate from the ground surface to the underlying water table. Such migration could decrease groundwater quality, which could impact an existing use, such as a water supply. The determination of impacts is therefore dependent on specific site characteristics, local uses, and project details. Leaching of nitrate is most likely to occur due to the large quantity of newly-available nitrogen and the ease of nitrate migration in a soil column. Possible impacts from nitrates are:

- health hazard to water supplies
- nutrient enrichment of surface water bodies which receive groundwater flow

Land Use. The application of sludge to forestlands would not change existing land uses on the application sites or in the surrounding area in the short run. The effect of sludge application on future land uses is uncertain and depends on specific uses likely to be proposed for sludge application sites. Certain land uses such as agricultural food crop production could be precluded in the future because of high concentrations of heavy metals and organic compounds in the soil.

Mitigation Measures. Mitigation measures to control erosion, compaction, and topsoil removal are generally similar for all potential sludge application sites; these measures are discussed in the Pilchuck project impact assessment later in this chapter. Additional site-specific measures should be developed on a case-by-case basis.

Surface Water -- Care should be taken in the project design to prevent adverse impacts to surface waters. A complete investigation of the water resources associated with a proposed site is necessary to allow for inclusion of possible mitigation measures. Once the resources have been established, buffer (nonapplication) zones, application rates and timing, facility locations, and other project features can be modified to provide sufficient protection to surface waters.

Verification of the actual application process is necessary to ensure that the designed mitigation measures are carried out. Training of sludge application personnel would decrease the possibility of an accidental application of sludge in a designated nonapplication area. A surface water monitoring program carried out before, during, and after after application is necessary to establish the impact of sludge constitutents. If, during application, a significant surface water impact is detected by the monitoring, corrective measures can be implemented.

For planning and cost comparison purposes, Metro has assumed and included in project cost estimates, the following monitoring features for any interim or full-scale silvicultural application project:

- One soil sample per 200 net acres of sludge-applied land with sampling every 2 years for a 5-year period following last application.
- One surface water sample per 250 gross acres with samples taken monthly for 2 years following last application.
- One shallow groundwater well per 20 net acres and one deep well per 300 acres with monthly sampling for 1 year (shallow well) and 5 years (deep well) following last sludge application.
- One plant tissue/growth response monitoring site per 200 net acres with remeasurement every 2 years.

The actual monitoring program necessary for each silvicultural application site would depend on site-specific factors such as proximity of the application area to a drinking water source, existing groundwater quality, proximity to surface waters, type of soil and the soil CEC as well as other features.

Groundwater -- A detailed understanding of the groundwater conditions and uses associated with a proposed project site should be incorporated into project design. This would allow for measures to be taken before a problem occurs in an aquifer. Preventive measures which should be considered are:

- modify application rate
- modify application schedule
- modify application areas

Land Use -- An adequate buffer zone surrounding the sludge application sites should be provided to protect area residents and land uses from possible adverse impacts.

Soil Improvement

Description of Existing Conditions. Metro (1983a) has defined potential soil improvement sites located 10-180 miles from the Renton and West Point treatment plants. Potential soil improvement sites could include: surface mines, gravel pits, landfills, and powerline rights-of-way. During excavation activities surface soils of surface mines, gravel pits and landfills are often removed, exposing coarse mineral subsoils. Surface soils of powerline rights-of-way are usually disturbed but generally not removed.

Surface Mines -- In 1979, there were approximately 170 surface mines within the area being considered for sludge disposal (McFarland et al. 1980). These mines cover approximately 4,500 acres and consist mainly of basalt, andesite, clay, and coal mines in western Washington.

The WIDCO surface coal mine near Centralia is one of the largest surface mines in the state. By 1982, a total of 3,300 acres had been mined. Since 1978 Metro has been hauling sludge to the WIDCO site for use as a soil improvement. During 1982 Metro was under contract to provide approximately 22,000 wt of sludge to storage lagoons at the WIDCO site. Sludge is temporarily stored and then applied at two different rates; 15 tons per acre per year on subsoils and 50 tons per acre for surface soils. Metro sludge is used only for topsoil improvement for eventual forest crop production. Sludge is applied through soil injection 8-16 inches deep on 300 acres annually. A grass cover crop and eventually Douglas-fir seedlings are planted on the reclaimed soil.

Sludge delivered to the WIDCO site by Metro is stored in existing storage lagoons at several locations on the WIDCO property. WIDCO personnel transfer sludge to a modified 4-wheel drive application vehicle with a 5,300-gallon capacity sludge storage. The vehicle applies sludge approximately 2-3 feet below the soil surface through a subsurface injection system.

The use of sludge for land reclamation at WIDCO is an ongoing activity permitted by Lewis and Thurston Counties. Both counties have approved the proposed facilities, application methods, application rates and monitoring programs for the use of sludge. WIDCO has completed the environmental checklist and both the Lewis County Health District and Thurston County Human Services Department have made declarations of nonsignificance as defined under RCW 43.21C.030(2)(c).

A hydrologic and soils monitoring program is currently carried out by WIDCO. Groundwater wells below each application area are sampled and analyzed monthly for nutrients and bacteria, and semi-annually for heavy metals and persistent organics (WIDCO 1982a; 1982b). Results of the sampling are sent to the county and DOE each month.

The WIDCO soil improvement program has been approved by Lewis and Thurston Counties. Permits are issued yearly, and Thurston and Lewis Counties and DOE receive monthly monitoring reports. WIDCO is to release its five-year operation plan in 1983, along with a more general plan for operations to the year 2015 (Hickey pers. comm.).

Based on contacts with nine cities and municipalities in the vicinity of the WIDCO site, only two, Olympia and Metro, have plans for using WIDCO for sludge application in the near future (Kolby; Barkman; Price; Batterby; McCartny; Hyde; Layman; Thom; Hynes pers. comm.). The City of Olympia has an approximate 15- year agreement with WIDCO to provide 6.5 dry tons of sludge daily, or approximately 24 percent of the calculated sludge need by WIDCO (Kolby; Hickey pers. comm.).

Sand and Gravel Pits -- In 1979 there were approximately 400 sand and gravel pits within the 10-180 mile radius of Seattle (McFarland et al. 1980). Pit size varies considerably, but the average size is approximately 5 acres. Approximately 2,000 total acres of gravel pits are located in western Washington.

Landfills -- Landfill sites in the immediate King County area include the Cedar Hills (920 acres), Duvall and Midway landfills. Sludge from Metro treatment plants has in the past been used as top dressing at Cedar Hills and Duvall.

Rights-of-way -- Within the 10-180 mile radius of Seattle are approximately 70,000 acres of transmission rights-of-way operated by the BPA. Other rights-of-way in the area are maintained by Puget Power Company and Seattle City Light.

Assessment of Impacts. Metro has identified two potential soil improvement alternatives - Alternative 8A, Soil Improvement of Public or Private Land and Alternative 8B, Soil Improvement at WIDCO. Sludge would be stored in either lagoons in the Kent Valley (Alternative 8A) or at storage lagoons at WIDCO.

Application of sludge for soil improvement would be oriented toward providing an additional organic and nutrient content to mineral subsoils or soils affected by construction activities. The objective would be to provide a medium for rapid growth of vegetation to stabilize soils that would otherwise be susceptible to erosion.

The use of sludge on surface-mined lands could be considered a valuable asset for any program of site vegetation. The State of Washington rules and regulations pertaining to protection and restoration of lands disturbed through surface mining state that "Revegetation shall be required only where it is appropriate to the intended subsequent use of the surface-mined site, or where, on a temporary basis, it is needed to provide soil stability, to prevent erosion, or to provide screening" (Board of Natural Resources 1970).

The federal Surface Mining and Control and Reclamation Act of 1977 (30 CFR Section 700) requires rehabilitation of surface mines throughout the United States. One specific section of the Act entitled Nutrients and Soil Amendment (Section 715.16 2D) would be particularly pertinent to the use of sludge for rehabilitation of surface mining sites. That section states that nutrients and soil amendment, in amounts and analyses as determined by soil tests, should be applied to the surface soil layer so that it will support postmining land uses and requirements of site revegetation.

Storage Lagoons -- For Alternative 8A, storage lagoons would need to be constructed at a location central to soil improvement sites. The selected site would need to be situated in an area remote from possible incompatible land uses (e.g., residential, commercial or recreational uses) and sensitive odor receptors. The DOE's BMP identify lagoon design and construction considerations needed to achieve proper sludge handling and management.

For Alternative 8B or for alternatives involving application of sludge as a landfill top dressing, lagoons provided by the soil improvement site or landfill owners and operators would be utilized as storage areas by Metro.

Site Selection -- Selection of sites for sludge application under Alternative 8A would require Metro to follow its plan implementation process previously described in Chapter 2 of this EIS. According to DOE (1982a), critical factors to consider in site selection include groundwater and surface water systems, background water quality, geology, site physiography and topography, physical and chemical properties of surface soils, and surrounding land uses.

Sludge Application Rates -- Metro would need to determine the likely vegetation to be grown on the site and whether the vegetation would be used as animal feed, for human consumption, or for nonfood-chain uses (e.g., timber production). EPA (1979c) and DOE (1982a) have established allowable heavy metal loading requirements per acre for land to be used to grow crops for direct human consumption. In addition, if crops are to be grown as feed for animals whose products are consumed by humans, pH adjustments equal to or greater than 6.5 would be required. Analyses of allowable cadmium loading were presented in the Agricultural Application section of this EIS and will not be repeated here.

At the present time no regulations apply regarding allowable heavy metal loading for nonfood chain uses on soil improvement sites or when sludge is used as a top dressing for landfills. Loading rates have been established by such factors as annual nitrogen requirements to grow the vegetative cover (e.g., ryegrass, fescue or Douglas-fir seedlings) or best estimates of what quantities of sludge could be applied without causing environmental problems (e.g., significant nitrate backing or phytotoxicity).

Land Use -- One of the more important considerations for soil improvement would be the compatibility of the proposed sludge application activity with surrounding land uses. While most surface mines, gravel pits, and landfills are likely to be situated in an area where surrounding land uses are compatible, many powerline rights-of-way lie immediately adjacent to high density residential and commercial uses.

One other consideration is that of future use of the soil improvement sites once sludge application has been completed. Since soil improvement sites often have high sludge application rates (e.g., 15-50 dry tons per acre), some future land uses (specifically the use of the site for growing food chain crops) may be precluded. If sites were to eventually be used for residential development, some restrictions of use may be necessary (i.e., backyard gardening).

Compatiblity with Site Activities -- Any sludge utilization activities on lands used for other purposes would need to be compatible with the primary uses. For example, sludge would need to be supplied for gravel pit or surface mine restoration so that adequate time would be allowed for vegetation growth following application. Additionally, the use of sludge on powerline rights-of-way may have an effect on vegetation management carried out by the power companies, and the use of sludge at landfill sites could interfere with primary day-to-day activities.

Monitoring -- For Alternative 8A, Metro would be responsible for soil and water site monitoring. As a minimum, DOE (1982a) recommends that, based on site-specific conditions, "Surface water that flows from a sludge-treated area should be sampled above and below the point it mixes with receiving streams. Groundwaters should be monitored from wells both up-gradient and down-gradient from the sludge treated areas. Soil samples should be taken from sludge application sites before applying sludge and again after the total maximum safe sludge applications have been made."

Sites to be used for soil improvement would be subjected to the SEPA process, and an environmental checklist and/or and EIS would be prepared by Metro as needed.

Mitigation Measures. The DOE Best Management Practices (1982a) provide some general guidance for proper site evaluation, management and monitoring. Measures specific to the requirements of each proposed soil improvement site would be a necessary part of any EISs prepared for those projects.

Because of the concern for future uses of soil improvement sites the following mitigation is suggested:

- Future property owners should be notified by a stipulation in the land record or property deed which states that the property has received sludge at high cadmium application rates and that food chain crops should not be grown, due to a possible health hazard.
- Metro should keep an accurate record of the locations, dates of application, quantities and quality of sludge applied on all soil improvement sites utilized.

Economic Impacts of Metro's Preferred Long-Range Alternatives

Metro has identified its recommended plan as a combination of the four broad sludge management categories (agricultural application, composting, silvicultural application, and soil improvement) previously analyzed in this chapter. The impacts associated with sludge processing, hauling, sludge storage application and monitoring for each category were considered previously in this chapter, and will not be restated here.

User Rates

One feature of the plan not analyzed in the previous discussions was costs of the Draft Sludge Management Plan to the user within Metro's service area. Funding for the costs of construction and operation and maintenance of the sludge processing and application program would be provided by a combination of federal and state construction grants, local revenue bonds, and monthly sewer service fees.

For approved capital facilities, for which funding is available, federal grants can pay up to 75 percent of the eligible cost, state grants up to 15 percent, and local funds 10 percent. If the project is classified as innovative and alternative by the EPA, the federal grant can increase to 85 percent, the state grant becomes 9 percent, and the local share decreases to 6 percent. In the past, Metro has sold revenue bonds to finance the local share of the capital costs, and then repaid these bonds using a portion of the Metro monthly charge.

Annual operation and maintenance costs are paid for by Metro, and no grant funds are involved. Operation and maintenance costs are paid for by a portion of the monthly charge collected by Metro. The 1983 monthly base rate is $5.85.

For purposes of the Sludge Management Plan, Metro determined a year 1990 total base monthly rate of $3.20 per customer for construction and operation and maintenance of in-plant sludge processing at Renton and West Point, and costs associated with sludge hauling, storage application, and site monitoring. The estimated split of costs for in-plant and sludge management (application) would be as follows:

- In-plant costs (67.2 percent) - $2.15
- Sludge hauling and ultimate disposition (32.8 percent) - $1.05

The base monthly rate of $3.20 is an average and would vary, depending on the sludge disposition category selected. Table 3-7 presents the range of total base monthly rates for each category. The total year 1990 Metro monthly sewer rate per customer would be approximately $15 per month, depending on the category finally chosen.

Impacts of Metro's Near-Term Plan

Metro's near-term plan will consist of a five-year plan and a one-year plan. The five-year plan has not yet been prepared and therefore is not evaluated in the Draft EIS. According to Metro, the final facilities plan, to be completed in June or July 1983, would specifically identify anticipated strategies to meet the five-year planning goals of sludge disposition: soil improvement, 35 percent; composting, 25 percent; silviculture, 25 percent; and agriculture, 15 percent (Metro letter to DOE 1982b). The Final EIS will evaluate the impacts of the five-year plan.

Metro's 1983 plan (one-year plan) would include use of five sludge application sites for which permits currently exist (WIDCO, Pack Forest, GroCo, and Cedar Hills and Duvall landfills); the Pilchuck Tree Farm (permits in progress); and other sites not yet identified. The impacts of operations at the permitted sites are not evaluated in this EIS because SEPA requirements (environmental checklists and/or environmental impact statements) have been previously met and because no federal funding is proposed for continued operations at these sites. Documents associated with past environmental analyses of those sites are available for review at Metro's Environmental Planning Division. An impact analysis of the Pilchuck demonstration project immediately follows this section.

Table 3-7. Projected Monthly Base Rates for the Long-Range Sludge Management Alternative (Year 1990)

Management Alternative	Monthly Base Rate
Agricultural application	$2.42 to $2.98
Composting	$3.02 to $3.15
Silvicultural application	$2.63 to $3.60
Soil improvement	$2.22 to $2.90

SOURCE: Metro 1983a.

Impact Analysis of the Pilchuck Tree Farm Demonstration Project

Introduction

The following impact analysis is based on the description of the Pilchuck Tree Farm sludge demonstration project prepared by Metro (1982) and briefly presented in Chapter 2 of this EIS. The proposed sludge application sites are shown in Figure 3-1. A detailed description of the proposed demonstration project appears as an appendix to Metro's Sludge Management Plan.

This impact analysis consists of evaluations of impacts of a no-action alternative, construction-related impacts, and operation-related impacts.

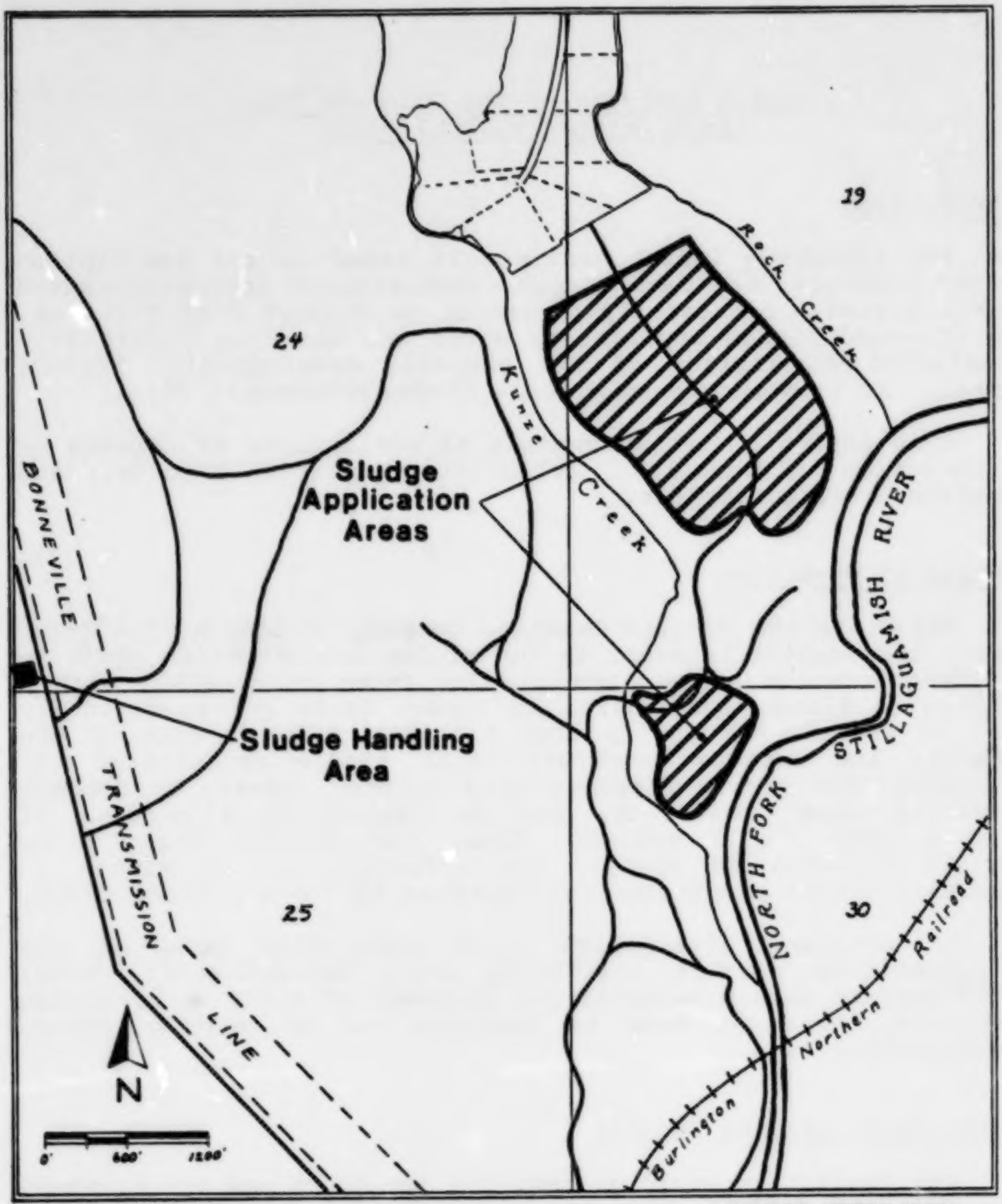
Impacts of No-Action

Metro and the Pacific Denkmann Company (Pilchuck Tree Farm) have a cooperative interest in the sludge demonstration project. The demonstration project would allow Metro to continue with a program of sludge application on forest lands and specifically to: 1) provide the public with a better understanding of the benefits and impacts associated with sludge application, 2) determine tree growth response on a managed forest, 3) conduct intensive site monitoring, and 4) land-apply a portion of Metro's 1983 sludge volume. Also, the project would allow Pacific Denkmann to analyze the effectiveness of sludge in improving timber production on a portion of the Armstrong tract.

A no-action alternative would mean that none of the aforementioned project objectives would be achieved. Metro would need to secure capacity for disposal of 8,000 wt of sludge elsewhere and might have to initiate use of another forest demonstration site.

Construction-Related Impacts

Few facilities would be required for Metro and the Pilchuck Tree Farm to conduct the sludge demonstration project. Metro has identified 4 storage alternatives (1 MG storage basin, 0.25 MG basin, reusable tank and a trailer) and access roads as the only construction features of the proposed action. Table 3-8 presents the construction-related impacts associated with each storage alternative and the access roads.



19
Rock Creek
24
Kunze Creek
Sludge Application Areas
BONNEVILLE
TRANSMISSION
LINE
NORTH FORK STILLAGUAMISH RIVER
Sludge Handling Area
25
30
Burlington Northern Railroad
N
0'
600'
1200'

SOURCE: METRO,1982d

FIGURE 3-1
Proposed Sludge Application Sites and Facilities, Pilchuck Tree Farm, Arlington, Washington

Table 3-8. Construction-Related Impacts of Storage and Access Road Construction
Pilchuck Tree Farm

	Storage Alternatives					
Impacts	1 mg Lagoon	0.25 mg Lagoon	Reusable Tank	Trailer	Access Roads	Mitigation Measures
Clearing, grading, soil removal and disposal	0	0	-	-	0	Disposal of spoil material in a manner to avoid impairment of surface water bodies.
Erosion	0	0	-	-	0	Construction activities only during dry months.
Soil compaction						Use of low pressure tires on construction vehicles.
Potential runoff to surface water	0	0	-	-	0	Construction activities only during dry months. Use of straw bales and silt screens on any slope areas.
Vegetation loss	0	0	-	-	0	
Wildlife habitat loss	0	0	-	-	0	Construction during late summer or early fall to avoid nesting birds.
Noise	0	0			0	Use of noise control devices on construction equipment; construction carried out only during daylight hours.
Light and glare	-	-	-	-	-	Construction carried out only during daylight hours.
Recreational uses	-	-	-	-	N/A	Portions of the site would be closed to recreational uses; warning signs on roads leading to construction site.
Aesthetics	N/A	N/A	N/A	N/A	0	None needed - site will be isolated from sensitive receptors.
Construction-related employment	+	+	+	+	+	

NOTES: + = beneficial impact; x = severe adverse impact; 0 = moderate impact; - = minor impact; N/A = no impact.

Geology and Soils

Description of Existing Environment.

Geology -- The surface geologic and topographic features of the Pilchuck site are the result of a series of glaciations that began about one million years ago. The most recent of these glaciations, the Fraser, occurred between 10,000 and 25,000 years ago. In addition to shaping the land, the Fraser glaciation deposited thick layers of sand, gravel, and silt over the sedimentary bedrock.

As the glacier advanced, it overrode the soil and rock mixture it was pushing, forming a dense layer known as compacted glacial till. This material varies from 20-150 feet in thickness and underlies the Armstrong tract of the Pilchuck Tree Farm.

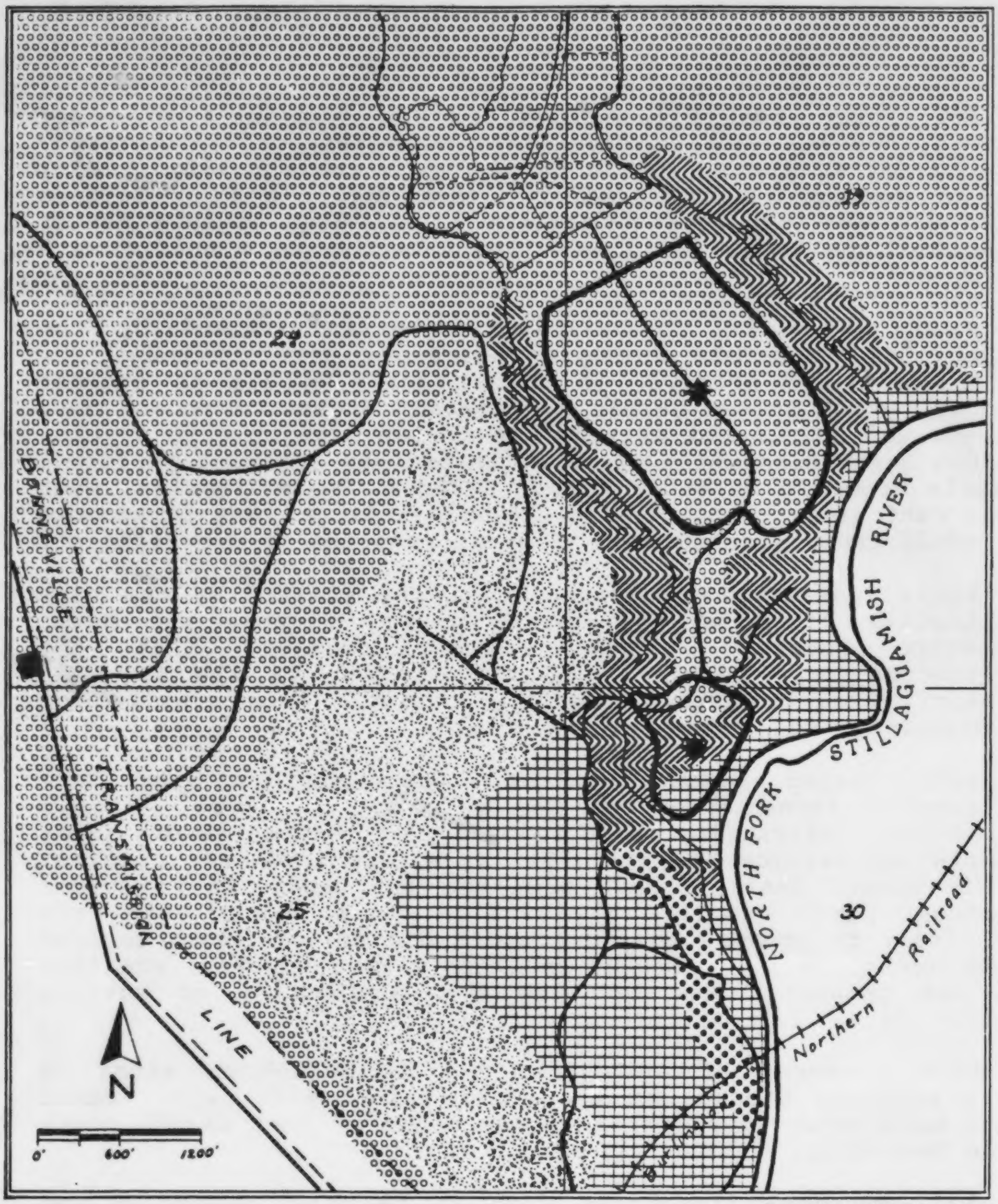
Meltwater streams, active as the glacier began its retreat, are responsible for the deposition of a poorly sorted, excessively drained mixture of sand, silt and gravel known as the Vashon Recessional Outwash. This layer varies in thickness from 15-200 feet and was deposited on top of the glacial till.

The geology of the remaining areas of the Armstrong tract is dominated by the actions of the Stillaguamish River. Thick alluvial (water-formed) deposits of coarse sand and gravel intermixed with silt and clay underlie much of the southeast side of the Armstrong tract (Figure 3-2).

The two sites selected for the first applications of sludge are underlain by a mixture of recessional outwash, Vashon till and alluvial material (Figure 3-2). The northern site lies within the Vashon recessional outwash, whereas the southern site contains outwash in the northern portion, with till and alluvium in the southern half.

Soils -- In soils investigations conducted by Metro, Ragnar and Winston soil series were identified on the project site. Most of the Armstrong tract is underlain by Ragnar soils which are deep, well drained, and formed on glacial outwash. This fine sandy loam has moderately rapid permeability in the top 2-3 feet and rapid permeability in the loamy sand and sand that exists below the surface soil. Permeability is defined as "a quality of a soil that allows air and water to move through it" (SCS 1937).

The Winston series is similar to the Ragnar but the subsoil contains more gravel. The surface soil (to about 35 inches) consists of a loam and silt loam of moderate permeability. Below this, an extremely gravelly sand of very rapid permeability extends to a depth of over 60 inches.


24
19
25
30
BONNEVILLE TRANSMISSION LINE
NORTH FORK STILLAGUAMISH RIVER
Burlington Northern Railroad
N
0'
600'
1200'

SOURCE: METRO 1983d

legend

- ■ SLUDGE HANDLING SITE
- ✱ DEMONSTRATION SITES
- ▦ ALLUVIUM
- ▨ VASHON TILL
- ⁘ SEDIMENTARY BEDROCK
- ○ VASHON RECESSIONAL OUTWASH STILLAGUAMISH SAND MEMBER
- ⁚ VASHON RECESSIONAL OUTWASH SAND AND GRAVEL

FIGURE 3 - 2
Geologic Features of the Pilchuck Site

Soils on the Pilchuck site are similar to other glacially-derived western Washington with respect to chemistry and nutrient movement. Soils on the site are strongly acidic, with an average pH of about 5.3 (see Appendix C). Surface layers are the most acidic, reflecting the high organic matter content of the upper horizons. Soils become less acidic with depth.

Productivity on the Pilchuck site is limited by the availability of usable nitrogen (Staringer pers. comm.). The vast majority of nitrogen in forest soils exists as organic nitrogen, which is not usable by plants. Organic nitrogen must be converted to mineral nitrogen to become available to plants. Appendix B contains the results of laboratory analyses performed on soils from the Pilchuck site. Based on these results, none of the cations or metals tested appears to be present in amounts that would cause a deficiency or toxic reaction in tree species.

Soils loss from the Pilchuck site is limited by the high infiltration rates of the soils, gentle slopes, and heavy vegetative cover. Surface erosion requires that the infiltration rate of the soil be exceeded by the rainfall intensity, thereby causing surface runoff. This runoff must then encounter and detach soil particles.

Soil series present on the demonstration site have infiltration rates exceeding the majority of local rainfall intensities, restricting the possibility of surface runoff (Soil Conservation Service 1937, 1973). Tree farm employees consider surface runoff insignificant from the two demonstration sites (Staringer pers. comm.). The Winston soils (north site) are more likely to produce surface runoff due to the finer texture of the surface soils. Slopes on these areas, however, are less than six percent, thus reducing the possibility of surface runoff.

Mass movement of soil from the demonstration sites is highly unlikely because of the gently sloping terrain. Small slumps have occurred along the steep banks of Rock Creek, north of the two sites.

Soil physical properties such as texture, structure and aggregate stability also influence erosion. Coarse-textured soils such as Ragnar possess a low aggregate stability and are nearly structureless. These factors make the soil more susceptible to erosion. Although the finer texture of the Winston soils encourages surface runoff, it also promotes higher aggregate stability and the formation of an erosion-resistent structure.

Soil microorganisms are responsible for the decomposition of organic matter (including nitrogen transformations), transfer of nutrients to the plant root tips, incorporation of organic material, and improvement of soil aeration. Most of the activity takes place within 10 centimeters of the soil surface, and increases near root tips.

Soil organisms include microflora such as fungi, algae and actinomycetes, and microfauna which include protozoa, Collembola, Acarina, and Nematoda. Bacteria are also present in forest soils. The microflora, especially fungi, are responsible for the degradation of humus and the translocation of nutrients to the root hair of higher plants. Microfauna consume detritus and humus, but lack the enzymes for significant degradation of this material. Bacteria perform a number of functions, including the transformation of organic nitrogen into forms usable by forest plants. In acidic forest soils fungi are the dominant group of microorganisms (Miller in Sopper and Kardos 1973). In western Washington soils, microfauna are limited mainly to Collembola (springtails) and Acarina (mites) (Mayer 1980). Although bacteria are vital to many soil processes, their numbers are limited by the high carbon to nitrogen ratio, acidic conditions and low temperatures of area soils (Trappe and Bollen in Heilman et al. 1979). Their low numbers are partially responsible for the buildup of organic nitrogen and the paucity of usable mineral nitrogen.

Assessment of Impacts.

Geology -- There should be no operation-related impacts to the geologic features of the area.

Soils -- Digested, dewatered sludge possesses physical and chemical properties which are significantly different from those of forest soils. In the forest, sludge is initially viewed as an anaerobic layer of organic material with high pH, nutrient and metal content, low carbon to nitrogen (c/n) ratio and a high waterholding and cation exchange capacity.

The impacts of sludge application on the physical properties of forest soil have received some study. Immediately upon deposition, sludge may cause a temporary lowering of the soil's infiltration rate due to surface sealing (Kirkham 1974). This condition would be most prevalent where large trees and a minimum of undergrowth allow a more even coverage by sludge. Due to the relatively small amount of sludge applied, roughness of the forest floor, cracking of the drying sludge and the high antecedent permeabilities of Winston and Ragnar soils, decreases in soil infiltration rates on the demonstration sites would be slight and temporary (Henry pers. comm.).

Sludge application is known to improve soil structure, aggregation and texture, especially on sites with coarse soils (Epstein 1973). This results from the great number of organic particles present in sludge. Improvements in these soil properties will increase water and nutrient-holding capabilities, erosion resistance, and drought resistance.

Additional impacts to the physical properties of the soil would result from the movements of the sludge application vehicle through the forest. Surface soil areas traveled by the vehicle would be compacted, resulting in lowered infiltration rates, reduced porosity and possible surface ponding. Compaction would be greatest on wet soils and on those areas which have not been exposed to vehicle traffic in the past. These areas would include the southern half of the north site and the majority of the south site.

Digested dewatered sludge contains large amounts of nutrients and heavy metals as compared to forest soils (Table 3-9). These characteristics are responsible not only for potential increases in tree growth, but also for the alteration of a number of soil chemical properties and processes including:

- pH
- CEC
- mechanisms for cation movement
- nitrogen cycling
- heavy metal concentration and movement
- concentrations of organic toxins

A brief summary of potential impacts of those factors is presented here, but the reader should consult Appendix B for a complete discussion.

Sludge pH is considerably higher than that of the demonstration sites' soils (Table 3-9). Upon sludge application, surface soil pH increases in response to the more alkaline sludge. As decomposition proceeds, however, sludge and soil pH declines and may reach values below that of the original soil before returning to background levels (Edmonds and Mayer _in_ Bledsoe 1981).

The CEC is the ability of a soil to adsorb positively charged ions (cations). Because sludge contains large quantities of negatively charged organic colloids, the CEC is significantly greater than that of coniferous forest soil (Zasoski pers. comm.). As these organics are incorporated into the soil, the soil's ability to bond positively charged nutrients and metals would increase (Edmonds and Cole 1977).

Sludge application dramatically increases the concentration of cations in the soil. Although many of these are adsorbed in the upper soil horizons or utilized by vegetation, some may be subject to leaching. To move through the soil, these cations

Table 3-9. Comparison of Chemical Characteristics of the Pilchuck Tree Farm Soil and West Point Digested, Dewatered Sludge

	Sludge	Soil*
pH	7.4	5.3
Nutrient Levels (% of dry weight)		
Organic-N	3.4	0.31
Total P	1.5	0.26
Total K	0.15	0.054
Metals (mg/kg)		
Cadmium	46.0	1.6
Chromium	390.0	40.0
Copper	1,160.0	13.0
Lead	720.0	21.0
Mercury	6.2	.22
Nickel	155.0	45.0
Zinc	1,780.0	59.0
PCB (mg/kg)	1.6	N.D.

NOTES: * Soil values taken from Metro sampling 5/82-7/82 (see Table -).

Complete digestion used for heavy metal determinations.

N.D. = none detected.

SOURCE: Metro 1983d.

must bond with a negatively charged particle or anion. Nitrogen transformations following sludge application (Appendix B, nitrogen cycling) may produce the mobile anion nitrate in large enough quantities to facilitate the loss of some of the added cations.

Alteration of the forest's nitrogen cycling capabilities is one of the major impacts of sludge application. Sludge application is likely to result in the following:

- o increased vegetative uptake
- o increased nitrate leaching
- o increases loss of gaseous nitrogen
- o increased soil storage of nitrogen

Sludge application would also increase the concentration of heavy metals in the soil. Metals added to soils through sludge application may succumb to the following fates:

- o vegetative uptake
- o bonding by organic polymers in the upper soil horizons
- o bonding by metal oxides throughout the soil profile

The trace metals to be added to the soil would include those listed in Table 3-10. Extensive research has shown that the majority of metals are bound in the upper soil layers and seldom move into the mineral soil or groundwater (Henry and Cole 1983; Williams et al. 1980). Other considerations such as groundwater and surface runoff are evaluated elsewhere in this EIS.

Organic toxins including pesticides and herbicides may be added to the soil when sludge is applied. Although the exact fate of these materials is not known, the mobility within the soil is greatly restricted due to their low solubility in water (Darce in Bitton et al. 1980). Humic substances found in the soil's organic surface layer adsorb the toxins readily, preventing their movement into plants or through the soil profile (Bailey and White 1970; Lichtenstein 1971). Adsorbed to the soil organic layer, the toxins are subject to volatilization, and photochemical and microbial decomposition. The high organic matter content of soils on the two demonstration sites should help prevent significant movement of these toxins within the system.

Sludge provides a sediment source that is exposed to the erosive forces of rain and surface runoff. Because sludge possesses unique physical characteristics, it reacts quite differently to these erosive forces than does a layer of applied soil. The high organic matter content of sludge acts as a binder, holding sludge particles together. Sludge contains about 27 percent organic carbon (a measure of organic matter) compared to about 5 percent for the surface of glacially-derived soils (Mayer 1980). Even if sludge particles became detached, a mechanism for transport is still needed. It is unlikely that surface runoff capable of transporting detached sludge particles could develop on the nearly level, porous soils of the demonstration sites (see Soil Impacts, Physical Properties and Soil Existing Conditions, Erosion).

Mass movement (e.g., slumps, slides) of sludge is also unlikely, provided sludge is applied only to the relatively flat demonstration sites. Tilting table experiments have shown that 1 inch of sludge applied to a forest floor resisted movement on slopes up to 42 percent (Henry pers. comm.). Slopes on the demonstration sites do not exceed 10 percent.

The following two properties of sludge are important to the microbiological resources of the soil:

- high pH
- low carbon/nitrogen ratio

In areas where sludge can be applied uniformly (older stands having a minimum of ground vegetation) temporary, anaerobic conditions may facilitate a short-term drop in the populations of soil organisms. In the freshly applied sludge, bacteria are the dominant life form, with almost no fungi present (Miller *in* Sopper and Kardos 1973). Although initial colonization of the sludge by fungi is slow, the most significant decomposition of the sludge would take place in the first month (Edmonds and Cole 1980).

As litterfall and nitrogen removal combine to raise the carbon/nitrogen ratio and lower the pH of the decomposing sludge, fungi will begin to invade the sludge. Mayer (1980) found that 3 months after application aerobic conditions dominated the sludge applied under a forest canopy. After 6 months, sludge fungi and Collembola populations reached those of unsludged control plots. By 12 months, fungi populations in sludge soils were higher than those of the control (Mayer 1980).

Microbial populations at the Pilchuck sites may require less time to invade the sludge because of the reduced rate of sludge application compared to the studies cited above. Populations of microorganisms should remain high for a number of years due to the increased organic matter added by the sludge, as well as that furnished by the increased growth and litterfall of vegetation (Mayer 1980). Edmonds and Cole (1980) estimated that 2 inches of sludge would require 33 years for 99 percent of the organic matter to decompose. Faster rates of organic matter decomposition may be expected on the Pilchuck site due to smaller application rates and increased amounts of rainfall.

Displacement of soil microorganisms by sludge-induced organisms is highly unlikely. Competition for microsites is fierce and the organisms present in sludge are not well suited to long-term survival in the hostile soil environment (Edmonds and Cole 1980).

Mitigation Measures.

- o Skid roads used to transport and apply sludge should be designed to alleviate possible ponding of water or concentration of surface runoff in areas close to streams or other surface water.
- o Monitoring of sludge should be conducted to ensure proper percentages of water, nutrients, metals, and organisms. This would help ensure that sludge would react as expected after it was applied.
- o Sludge application vehicle routes should be carefully selected to minimize the travel of the vehicle in the forest. This would help prevent soil damage such as compaction.
- o Sludge should not be applied to soils wherever larger areas of the organic layer may have been disturbed or removed. This would reduce the possibility of rapid movement of heavy metals or other contaminants through the soil profile.
- o Accurate and visible flagging of demonstration area boundaries to ensure that sludge is not applied to areas unsuited for coverage. This should help ensure that sludge will not be applied to areas with steep slopes, shallow soils, or high ground water levels.
- o Refraining from applying sludge during a heavy rain. This would reduce soil damage by the application vehicle and lower the risk of groundwater contamination and surface runoff.

Air Quality

Description of Existing Environment. Ambient air quality in the Arlington area is considered excellent. The area lies within the air quality attainment areas for suspended particulates, carbon monoxide, and photochemical oxidants (ozone).

The DOE has maintained ozone monitoring at the Arlington Fire District No. 22 Station and a suspended particulates station at Lake Stevens (PSAPCA 1981). Ozone concentrations have been below the National and Washington State ozone standard of 0.12 ppm (DOE 1982c).

Slash burning in forested areas often causes smoky haze. Odors from farming operations often dominate the area.

Assessment of Impacts. Depending on the sludge storage alternative selected, the sludge application project would require between 365 and 520 truck trips to haul 8,000 wt of sludge to the site. Each haul day, haul trucks would emit from 2.8-6.4 pounds of hydrocarbon (HC), 9.2-19.8 pounds of carbon monoxide (CO), and 31.2-70.2 pounds of nitrous oxide (NO_x) during transport from the West Point Treatment Plant to the Pilchuck Tree Farm. The number of haul days would range from 66-104, depending on alternative storage.

The removal of sludge from the storage area and application to the sites would require the use of a diesel powered sludge pump, nurse vehicle and application vehicle which would contribute minor HC, CO, and NO_x emissions to the local air basin.

Emissions from the haul trucks and sludge pump will be relatively minor compared to regional emissions, and are not expected to significantly affect ambient air quality. The emissions would be generated for the duration of the trucking and application of sludge (approximately one year).

The impacts of odors are presented in the Aesthetics section of this evaluation.

Surface Water

Description of Existing Environment. The near-term sludge demonstration site at the Pilchuck Tree Farm is bounded on three sides by streams; Rock Creek flows along the northeastern boundary, Kunze Creek flows along the western boundary, and the North Fork of the Stillaguamish River flows along the southeastern boundary (see Figure 3-3). No other streams or wet areas are located within the demonstration area.

Rock Creek and Kunze Creek are both approximately 5 miles long and drain approximately 825 and 1,350 acres, respectively. They flow generally southeast and discharge to the North Fork of the Stillaguamish. Neither creek has been gaged, but their flows have been estimated to vary between 1 and 90 cubic feet per second (cfs) (Metro 1983d). The North Fork of the Stillaguamish River is approximately 50 miles long and drains over 262 square miles upstream of the demonstration site. A U. S. Geological Survey (USGS) gaging station is located approximately 2 miles upstream from the demonstration site. Fifty years of flow data show an average flow of 1,891 cfs (USGS 1981). Table 3-11 summarizes the hydrological data of these three streams.

Water quality data on the North Fork of the Stillaguamish River have been collected by the USGS and DOE. The station is 3 miles upstream from the flow gaging station. Metro has summarized some of these data in Table 3-6 of the Demonstration Sludge Application Project Report (Metro 1983d). A complete summary of water quality data for the North Fork Stillaguamish is presented in Appendix F. Water quality data on Rock Creek and Kunze Creek have been collected by Metro and are presented in Table 3-12 (Metro 1983d). Existing water quality for both creeks is within the State of Washington surface water quality standards for Class A (excellent) water bodies (see Appendix F for those standards).

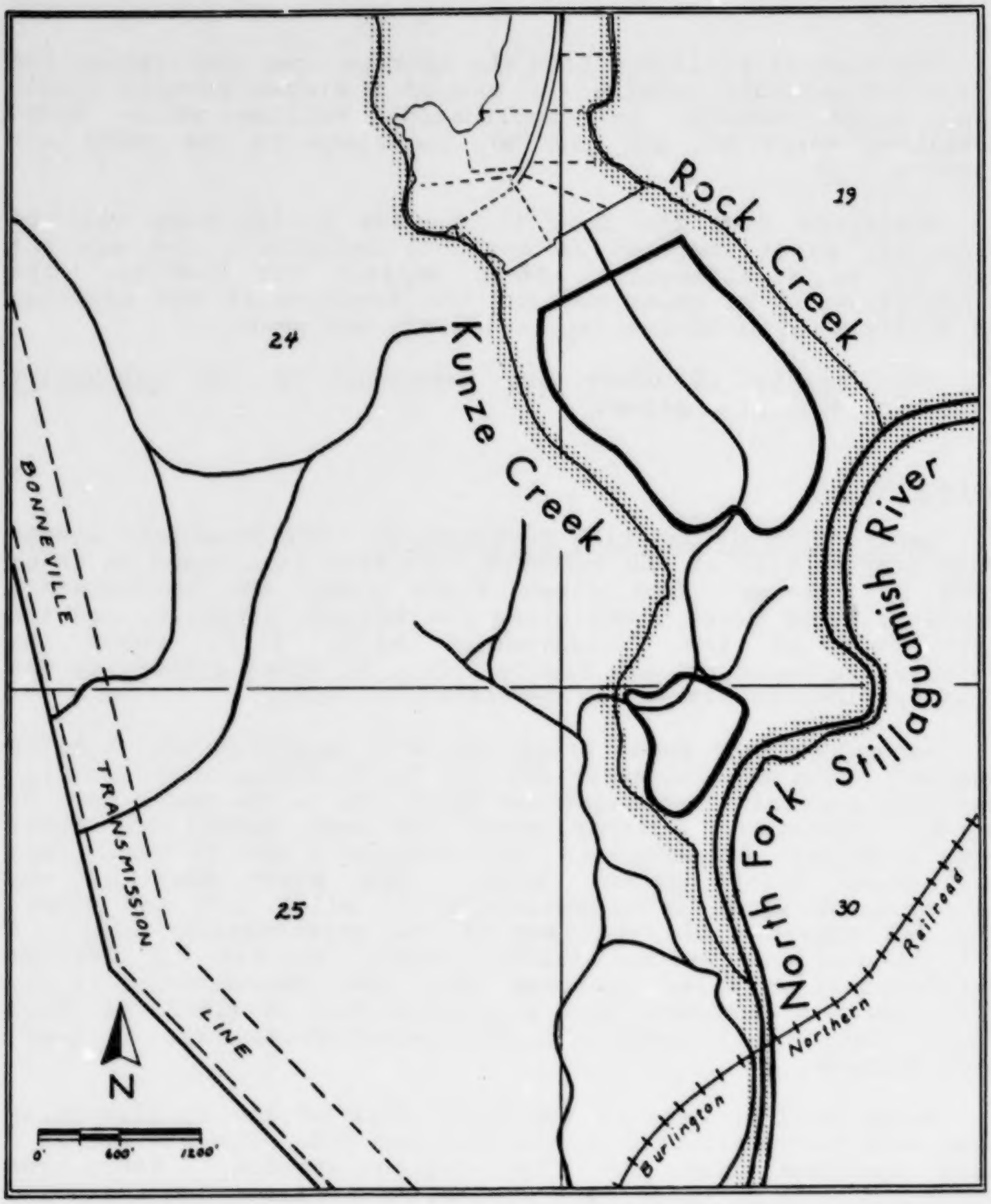

Rock Creek
19
24
Kunze Creek
North Fork Stillaguamish River
BONNEVILLE
TRANSMISSION
LINE
25
30
N
0'
600'
1200'
Burlington Northern Railroad

FIGURE 3-3
Surface Water Resources of the
Pilchuck Demonstration Project
Arlington, Washington

Table 3-10. Projected Loadings of Heavy Metals per Hectare, Pilchuck Demonstration Project[1]

TRACE METAL	HEAVY METAL CONCENTRATIONS IN METRO SLUDGE (mg/kg)[1]	KILOGRAMS/HECTARE (kg/ha)[2]	POUNDS/ACRE (lbs/acre)[2]
Arsenic	14.0	0.6	0.5
Cadmium	46.0	2.2	2.0
Chromium	390.0	18.4	16.6
Copper	1,160.0	54.6	49.1
Lead	720.0	34.4	31.0
Mercury	6.2	0.3	0.3
Nickel	155.0	7.3	6.6
Zinc	1,780.0	83.8	75.4

[1] See Table 2-3 for more detailed description of heavy metal concentrations in the Metro sludge.

[2] Based on application rate of 1 inch of sludge per acre.

Table 3-11. Hydrologic Data for Rock Creek, Kunze Creek, and North Fork of the Stillaguamish River

	Rock Ck.	Kunze Ck.	North Fork Stillaguamish
Length, miles	5	5	50
Drainage area, sq. mi.	1	2	292[2]
Average flow, cfs	1-90*	1-90*	1,891[2]
Average annual discharge	UK	UK	1,370,000[2]
Discharge to	N. Fork	N. Fork	Port Susan
Maximum flow, cfs	UK	UK	30,600[2]
Minimum flow, cfs	UK	UK	117[2]

NOTES: UK = unknown.
* = estimated range of flows.
[1] from WDOR Stream Catalog.
[2] from USGS 1981.

Table 3-12. Water Quality Data for Rock Creek and Kunze Creek
(Sampled March, May, June, July 1982)

Conventional Parameters	Unit	Rock Creek			Kunze Creek		
		Mean (n = 7)	Minimum	Maximum	Mean (n = 7)	Minimum	Maximum
NH_3-N	mg/l	.014	.002	.029	.021	.009	.032
NO_2+NO_3-N	mg/l	1.12	0.93	1.36	1.01	0.65	1.83
Total P	mg/l	.027	.013	.035	.030	.014	.043
Total K	mg/l	0.93	0.34	1.27	1.01	0.53	1.33
pH		7.3	6.8	7.5	7.2	6.7	7.5
Turbidity		0.82	0.3	1.6	1.5	0.5	2.8
Conductivity		52	39	69	55	44	70
Metals							
Cadmium	mg/l	--	<.0001[a]	.0019	<.0001	--	<.0001
Chromium	mg/l	<.012	<.001	.02	<.011	<.001	.03
Copper	mg/l	.0016	.0014	.0021	.0017	.0016	.0019
Mercury	mg/l	<.0002	<.0002	.0003	<.0002	<.0002	.0003
Nickel	mg/l	.012	.0004	.02	.0097	.0011	.033
Lead	mg/l	.02	<.02	.03	.03	<.02	.05
Zinc	mg/l	<.006	<.006	.025	<.006	<.006	<.006
Bacteria (Geometric means)							
Total Coliform	MPN/100 ml[b]	310	49	3,300	260	31	1,300
Fecal Coliform	MPN/100 ml	38	11	230	66	8	2,200
Fecal Streptococci	MPN/100 ml	240	36	490	440	130	1,300

NOTES: Viruses not analyzed until pumps can be installed (September 1982).
Parasites not detected in four samples tested (two Rock Creek and two Kunze Creek).
Chlorinated Organics not detected in four samples tested (two Rock Creek and two Kunze Creek).
Salmonella and Yersinia were isolated from Kunze Creek in one sample each.

[a] < = Less than

[b] MPN = Most Probable Number

SOURCE: Metro 1983d.

The North Fork of the Stillaguamish has been designated a shoreline of statewide significance and a Class A (excellent water quality) stream. Rock Creek and Kunze Creek should also meet Class A water quality criteria due to their discharge to the North Fork of the Stillaguamish River. Appendix F lists the state of Washington's Water Quality Standards for each water quality class.

Beneficial uses of the Stillaguamish River include irrigation, domestic water supply, stock water supply, fisheries, recreation, and limited navigation (Snohomish County Planning Department 1974). Rock Creek and Kunze Creek have the beneficial uses of fisheries and possible recreation.

Assessment of Impacts. Impacts of sludge application on surface water resources and water quality could occur if:

- Sludge is either directly sprayed or accidentally spilled into the three streams bordering the demonstration sites.
- Contaminated surface runoff from the application sites flows into the streams.
- Sludge was carried into streams as a result of soil erosion.
- Groundwater contamination led to surface water contamination.

Metro has designated minimum 100-foot buffer zones between the application areas and the three streams bordering the demonstration sites. Metro has also established a 25-foot sludge application setback from the edge of bluffs surrounding both sites. The actual horizontal distances from application areas to the edge of the three streams would range from a minimum of 180 feet (near the north site) to a maximum of 415 feet (south site near Rock Creek).

The possibility of sludge being sprayed into the buffer zone or streams would depend upon the distance of the application road from the edge of the bluff and the competence of the application vehicle operator. In the unlikely event sludge were distributed onto the slopes within a stream buffer zone it would be unlikely to move downslope any great distance. Research at Pack Forest showed that sludge applied up to 1.6 inches thick remains stable on forested slopes up to 42 percent (Henry and Cole 1983). Stream bank slopes on the site are less than 40 percent (USGS topographic quadrangle).

Under a worst-case situation sludge could conceivably enter Kunze Creek in the event the application or nursing vehicles spilled sludge on or near the bridge crossing from the storage lagoon to the application areas. If sludge were to enter the creek, the impact would depend on the amount of sludge spilled, the rate of entry into the creek, the stream flow, and such factors as BOD (biochemical oxygen demand) of the sludge. Sludge would probably be carried downstream and enter the North Fork Stillaguamish, where dilution would occur. Substantial dilution of any sludge entering the North Fork Stillaguamish would occur before reaching the City of Marysville public water diversion 5.5 miles west of the project site.

Contamination of surface runoff would occur if sludge constituents dissolve or are suspended in water as it flows over the application sites and enters the streams. Due to soil characteristics at the sites, very little over-the-land flow occurs, with the majority of precipitation percolating into the soils. Therefore, surface runoff would only be expected to occur during large storm events, which would also result in larger stream flows. Any impacts would be decreased by this additional dilution and overshadowed by natural pollutant increases during such a storm event.

An analysis of soil erosion potential is described in the Soils and Geology portion of this evaluation. The possibility of groundwater contamination leading to subsequent contamination of surface water is discussed in the following portion of this evaluation.

In its draft Pilchuck Tree Farm report, Metro identified the proposed site contaminant monitoring for the application sites (Table 3-13). The monitoring program would include monthly pre- and postsludge application monitoring for the parameters listed in Table 3-14 for Rock and Kunze Creeks and two springs located to the east and to the west of south site (Figure 3-4).

In the event monitoring of surface water indicated the presence of a parameter in excess of stream water quality standards (Appendix F), Metro would cease sludge application in the area where limits were exceeded and collect additional samples on a high priority basis. Based on the results of the further testing, Metro would consider the following alternative actions:

1. Provide water supply protection if any water supply wells may be affected.

2. Revise application plan by altering either the application rate, season of application, areas to receive applications, or a combination of these.

3. Proceed as planned with upgraded monitoring for contaminant movement.

4. Continue with original application plan if the evaluation indicates no significant increase in risk of affecting an aquifer used for water supply Metro (1983d).

Table 3-13. Pilchuck Tree Farm Preliminary Soil and Water Quality Monitoring Program*

Sampling Station Type	No. of Stations	Parameter Groups and Sampling Frequency[a]		
		Group 1	Group 2	Group 3
Primary Wells & Spring				
Test wells & Spring	3	B&A Monthly	L Quarterly	
Neighbors wells	4	B 4/year A 1/year	B Monthly A 4/year	
Lysimeters and Secondary Wells				
Old stand	5			B Monthly A Twice monthly
Young stand	13			F Weekly
Well 13	1			L Quarterly
Springs	2	B & A Bi-Monthly		B Bi-Monthly A Twice monthly F Weekly L Quarterly
Streams	4	B&A Monthly		L Quarterly
Soil and Sludge old stand	4	B&A Bimonthly	L Quarterly	
young stand	4	B&A Bimonthly	L Quarterly	
Lagoon Leakage Sump and Monitoring Well				B&A&L Monthly
Background Wells	9	B&A Bimonthly		

---

[a] Group 1 is all parameters
Group 2 is all conventional parameters, metals, and indicator bacteria (coliform and streptococci) - indicator parameters.
Group 3 is pH, EC, NO_2 and NO_3, and orthophosphate - tracer parameters.

[b] Selected secondary wells and springs will be monitored bimonthly for bacteria and metals before application to establish background conditions

Legend:
B indicates frequency before sludge application - background monitoring
A indicates frequency after sludge application - to continue for 12 months after application
F indicates during first flush of water moving through the soil profile
L indicates long-term followup - for period from end of first year to end of fifth year after application for wells and end of third year for all other stations

SOURCE: Metro 1983d.

NOTE: Subject to change depending on field conditions.

Table 3-14. Metro Contaminant Monitoring Project - Parameters

Conventional Physical and Chemical Parameters

- Organic N (Kjeldahl) (sludge/soil only)
- NH_3-N
- $NO_2+NO_3^-$
- NO_3^-
- Total P
- Orthophosphate P
- Total solids
- Volatile solids
- pH
- Turbidity
- Conductivity
- Fluoride

Organic Toxicants

- Aldrin
- Arochlor (PCB's)
- Chlordane
- DDT (4, 4'-DDT, DDD & DDE)
- Dieldrin
- Endrin
- Lindane
- Methoxychlor
- Toxaphene
- 2, 4-D
- 2, 4, 5-TP (Silvex)

Parasites

- *Ascaris lumbricoides*
- *Giardia lamblia*
- Others as identified in sludge

Metals

- Arsenic
- Barium
- Cadmium
- Chromium
- Copper
- Lead
- Mercury
- Nickel
- Selenium
- Silver
- Zinc
- Potassium[a]

Bacteria

- Salmonella
- Shigella
- *Yersinia enterocolitica*
- Mycobacteria
- Fecal Coliform
- Total Coliform
- Fecal Streptococci

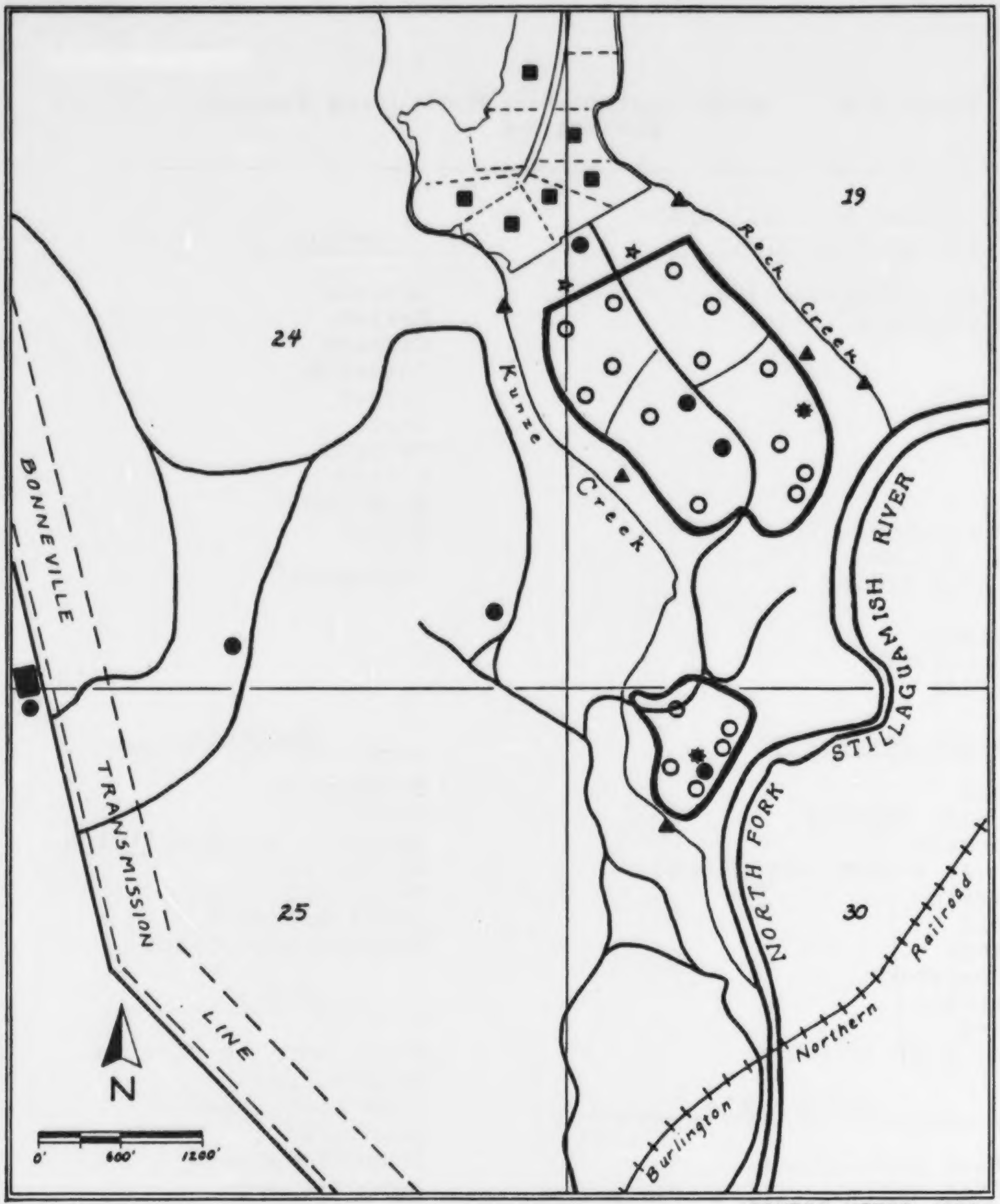
Virus

- Total enteric viruses
- Polioviruses
- Coxackieviruses B
- Echoviruses
- Coxackieviruses A
- Adenoviruses
- Reoviruses

---

[a] A nutrient analyzed with metals.

SOURCE: Metro 1983d.


19
24
25
30
Rock Creek
Kunze Creek
BONNEVILLE TRANSMISSION LINE
NORTH FORK STILLAGUAMISH RIVER
Burlington Northern Railroad
N
0'
600'
1200'

SOURCE: METRO, 1983d

FIGURE 3-4
Surface and Groundwater Monitoring Stations, Pilchuck Tree Monitoring Project

legend
■ HOMES
▬ STORAGE BASIN
● MONITORING WELL
✶ PIEZOMETERS
○ SHALLOW GROUNDWATER MONITORING WELL
▲ SURFACE WATER SAMPLING STATIONS
✹ SOIL/SLUDGE MONITORING STATIONS

The DOE's BMP (1982a) recommend surface water sampling upstream and downstream of the application site. Metro's proposed program would include such a sampling regime. Since monthly sampling will be done prior to and after sludge application for a wide range of parameters, Metro should be able to react quickly to any indication of contamination.

Mitigation Measures.

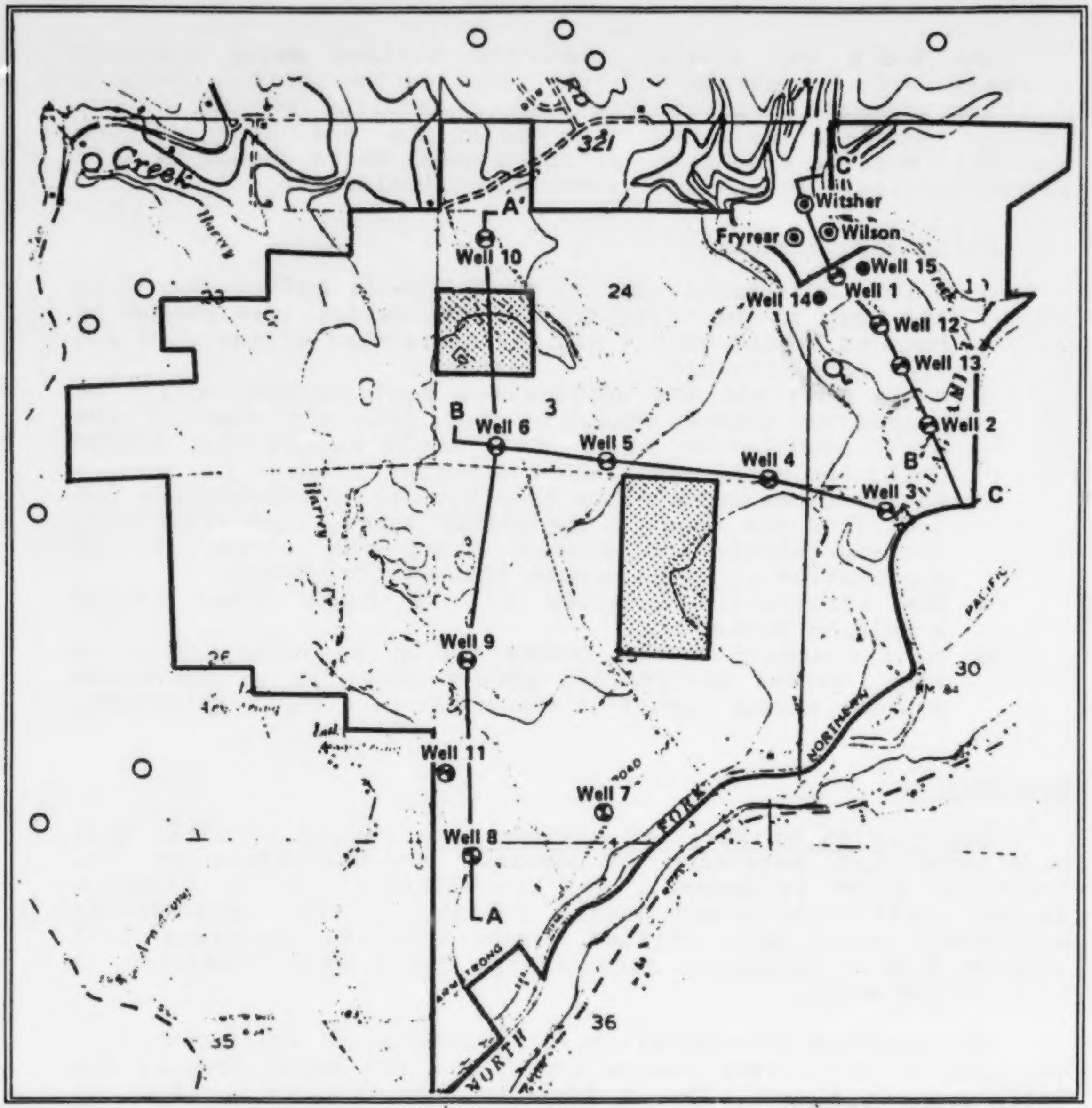
- Slight adjustments in the 25-foot-wide buffer zone from the edge of the bluff to the application area should be made to ensure that a minimum horizontal distance of 200 feet is maintained.
- Where possible the application road network should be placed no closer than 150 feet from the edge of the cliff-edge buffer zone. This would ensure that sludge could not be sprayed into the buffer zone.
- Wherever the application road network is closer than 150 feet from the edge of the buffer zones, high-visibility markers should be placed along the edges of the application sites to denote those buffer areas.
- The structural integrity of the Kunze Creek bridge should be determined.
- If the ground should freeze for an extended period of time, sludge application should cease as a precaution against sludge runoff in the event of a heavy rainstorm.

Groundwater

Description of Existing Environment. Metro and CH2M Hill have conducted extensive groundwater reconnaissance of the Armstrong tract in general, and specifically for the proposed sludge application areas (Metro 1982a). Fifteen groundwater monitoring wells were drilled during June to September 1982 (Figure 3-5). Hydraulic conductivity tests were conducted at nine of the wells.

The proposed demonstration sites overlie an aquifer that is isolated by Rock Creek, Kunze Creek, and the North Fork of the Stillaguamish River. The aquifer is underlain by a layer of Vashon till, which has low permeability and results in the occurrence of perched aquifers.

The aquifer is recharged from groundwater moving laterally downslope from the north, and from direct precipitation on the site. Groundwater tends to move east, south, and west, and discharge through springs and seeps along the cliffs and eventually into Rock Creek, Kunze Creek and the North Fork Stillaguamish River. The hydraulic gradient for sites has been approximated at 0.0143, or a drop in water level of 1.4 feet for every 100 feet of horizontal distance. An estimated 6,300 cubic feet of groundwater are discharged from the site each day.


A'
Well 10
321
Creek
C'
Witsher
Fryrear
Wilson
Well 15
Well 1
Well 14
Well 12
Well 13
Well 2
24
3
B
Well 6
Well 5
Well 4
B'
Well 3
C
Well 9
30
Well 11
Well 7
ROAD
Well 8
A
FORK
NORTHERN PACIFIC
NORTH
36
35
26
23
25

SOURCE: METRO 1982a

legend

Groundwater Monitoring Wells

- ⊖ 4-Inch Diameter
- ● 2-Inch Diameter

Domestic Water-Supply Wells

- ◉ Field Verified
- ○ Unverified
- ○ Spring
- ⌐ Hydrogeologic Profile
- ▨ Not Part of Site

FIGURE 3-5
Well Location
Pilchuck Tree Farm,
Arlington, Washington

The depth to groundwater is highly variable but, in general, it is shallowest at the north and south ends of the sites and deepest in the middle of the site (Table 3-15) (see Appendix F for a hydrogeologic profile of the site). Metro studies estimate the seasonal fluctuation of water table elevations to be from 1-6 feet.

Groundwater quality data have been gathered to provide preproject information for all parameters to be a part of the site monitoring program (see Table 3-13). Those data are presented in Appendix F. Samples were also taken from domestic wells located north of the site. Results of those tests indicate that the well water quality exceeds the drinking water standards for coliforms.

Assessment of Impacts. According to 40 CFR Part 257 (see Appendix G) "A facility or practice shall not contaminate an underground drinking water source beyond the solid waste boundary..." or any alternate boundary specified by the State. The aquifer beneath the Pilchuck sludge application site is considered to be an underground drinking source because, 1) it supplies drinking water for human consumption, and 2) the groundwater contains less than 10,000 mg/l total dissolved solids. As defined by 40 CFR Part 257, "contaminate" means to introduce a substance that would cause 1) the substance in the groundwater to exceed the maximum contaminant level specified by EPA in the Primary Drinking Water Standards (see Appendix F, Table F-6 or Appendix G Section 257.3-4 Groundwater), or 2) an increase in the concentration of that substance in the groundwater where the existing concentration of that substance exceeds the maximum contaminant levels specified in the Primary Drinking Water Standards.

The most likely impact of the proposed project would be associated with the movement of nitrate (NO_3-N) from sludge into the underlying groundwater. Research at Pack Forest has indicated that nitrate is the most likely constituent to leach to groundwater; (Vogt in Bledsoe 1981). Nitrate is very mobile and is generally the first pollutant to appear in groundwater. Edmonds and Cole (1982) have estimated a NO_3-N loss of 75 pounds per acre for the first year following sludge application (see Appendix B for a detailed description of nitrate leaching). Assuming a worst-case situation, approximately 5,400 pounds of NO_3-N may be leached from the site during the first year, approximately 15 pounds per day.

Studies have shown that in soils having relatively high hydraulic conductivity and few intrusions of impermeable materials (i.e., clay seams or large boulders), pollutants entering the groundwater tend to move laterally in a thin layer on the surface of the aquifer with little mixing below 5-10 feet of depth (Keeley pers. comm.). The contaminated zone deepens as the distance from the source increases; however, the NO_3-N concentration tends to become diluted as a result of dispersion and diffusion.

Table 3-15. Depth to Water, Hydraulic Conductivity and Water Level Elevations of Test Wells, Pilchuck Tree Farm Demonstration Project

Well Number or Owner	Well Elevation*	Depth to Water (Feet)	Water Level Elevation	Hydraulic Conductivity (Feet per Day)
1	1,000.0	53.3	946.7	11
2	852.2	22.3	829.9	33
3	881.5	-	-	-
12	979.7	57.1	922.7	-
13	967.9	46.1	921.8	-
14	992.0	48.0	944.0	-
15	997.2	52.6	945.3	-
Fryrear	1,003.6	23.7	979.9	-
Wilson	1,009.7	36.3	973.5	-
Witscher	1,019.1	13.1	1,006.0	-
Westerly Spring	918.3	0	918.3	-

*Well No. 1 elevation set by at 1,000 feet. All other elevations were established relative to that arbitrary reference elevation.

SOURCE: Metro 1982a.

Assuming a worst-case condition, based on University of Washington data, CH2M Hill calculated that sludge could contribute 5.9 mg/l NO_3-N beneath the site during the months of September through December. During the the year of application and for approximatley 1 year thereafter. During the remainder of each year nitrate values are expected to be lower because of seasonal percipitation and resulting groundwater recharge. Background nitrate levels directly beneath the site have not been measured, however, Metro collected groundwater quality data during 1982 from Well No. 1, just north of the site and from two adjacent springs (Figure 3-5). Average nitrate concentration from those sites is 2.4 mg/l, a value of which is probably representative of groundwater nitrate concentrations beneath the site.

With this assumed background concentration and the estimated 5.9 mg/l increase from the project, worst-case groundwater nitrate levels are estimated to reach 8.3 mg/l nitrate. This value is less than the EPA drinking water standard of 10 mg/l nitrate. Groundwater inflow from the north was not included in CH2M Hill analysis and would result in some dilution of the computed nitrate concentration. Nitrate concentration are expected to decrease significantly in the years following application.

Even though NO_3-N concentrations would increase with the project, no drinking water supplies would be affected since all private wells are located north and up-gradient of application areas. The water level elevation of a private well closest to the application site is approximately 27 feet higher than that of the closest monitoring well on the application site (Table 3-15).

Other pollutants such as heavy metals would not be expected to increase in concentration in the groundwater after sludge application. Fecal coliforms have been found to move from sludge into soil, but beyond 5 cm (approximately 2 inches) coliforms rarely survive (Edmonds and Mayer in Bledsoe 1981). However, because of the isolated nature of the aquifer, and the groundwater flow away from water supply wells, any increased concentrations of other pollutants would not affect any beneficial uses of the groundwater resource.

According to Metro (1983d), the larger of the storage alternatives, the 1 mg sludge basin, would be constructed with a 20-mil PVC liner to prevent leaching into the groundwater, and a leachate monitoring system of 4-inch perforated pipe to collect any material that might accidentally leak from the lagoon. Rainwater that might collect in the basin following removal and application of sludge would be spray-applied to approximately 5 acres of land near the sludge basin. During sludge trucking and application, the outside of vehicles would be washed on a concrete apron at the sludge handling site. Wash water would be collected and mixed with sludge in the sludge storage basin. No adverse impacts are likely to result from that activity.

Groundwater in the vicinity of the proposed location of the sludge basin trends southwest toward Harvey Creek. The estimated discharge of groundwater in that area is 46,000-69,000 cubic feet per day (Metro 1982a).

The rainwater collected in the empty sludge storage basin would be approximately 200,000 gallons per year. The water would be spray applied during the summer months when nutrient and moisture demand are greatest. An estimate of 100 pounds of NO_3-N would be applied per acre, well below the nitrogen requirements of an unfertilized Douglas-fir forest. On 5 acres of land, 200,000 gallons of water would be slightly less than 1 gallon per square foot of area. It is anticipated that virtually all of the water and nitrogen would be taken up by trees and understory vegetation.

Metro has defined a program to monitor groundwater quality based on sampling frequencies, parameters shown in Table 3-13, and the location indicated in Figure 3-4 that conforms with DOE's BMP (1982a) recommendations for groundwater sampling up and down-gradient from sludge-treated areas and testing for nitrogen, phosphorous, coliform bacteria, and other potentially harmful constituents.

Metro's proposed monitoring response plan would include action in the event groundwater from monitored domestic wells or site monitoring wells reached one-half of the maximum contaminant values in drinking water as allowed by EPA (40 CFR Part 257). This would allow Metro to initiate corrective action well before maximum allowable contaminant levels were reached.

Mitigation Measures.

- Metro should determine the best location for the rainwater spray application site to avoid any possible downstream contamination.
- Metro should establish a monitoring well to test groundwater immediately downslope of the spray application site.

Wildlife

Description of Existing Environment. Preliminary surveys of the wildlife resources of the Armstrong tract and 70 acres of the proposed sludge application area were made in 1982 by Dr. Steven West of the University of Washington and by Jones & Stokes Associates staff. The 70-acre site is characterized by blocks of even-aged 7-, 12-, and 24-year-old Douglas-fir, with some scattered western hemlock and grand fir. Salal, Oregon grape, blackberry, Indian plum and sword fern constitute the more common understory species in the plantation areas.

The proposed application areas are bordered by riparian vegetation (red alder, vine maple, salmonberry, blackberry, horsetail) along Kunze and Rock Creeks and the North Fork of the Stillaguamish River, and older growth Douglas-fir forests.

Wildlife resources include a variety of herbivorous, insectivorous, carnivorous and granivorous mammalian species. Mammals known to occur on the site include Townsend chipmunk, snowshoe hare, montane shrew, mountain beaver, striped skunk, blacktailed deer, raccoon, opossum, field voles, and forest deer mice.

No detailed site surveys of wildlife have been completed; however, the University of Washington will be initiating intensive baseline surveys as a part of the sludge application program to begin later in 1983 (Metro 1983d). Inventory work would include an intensive survey of seasonal and a relative abundance of vertebrates (birds, amphibians, reptiles, mammals). Specific investigations would include:

- Material balance study.
- Fecal studies of nutrients and heavy metals.
- Measurements of nutrients and heavy metals in soil-, ground-, and foliage-dwelling invertebrates.
- Measurement of heavy metals in tissue samples.

Avian species known or expected to occur in young-aged Douglas-fir forest include the red-tailed hawk, goshawk, common crow, black-capped chickadee, golden-crowned kinglet, winter wren, song sparrow, and band-tailed pigeon. A more extensive list of resident and seasonal bird species would be developed as a part of future University of Washington field surveys.

Although no site-specific field survey of reptiles and amphibians has been completed at the Pilchuck site, second growth Douglas-fir forest is known to support a variety of reptiles and amphibians. These include the northwest salamander, long-toed salamander, western red-backed salamander, western toad, and Puget Sound red-sided garter snake.

No endangered or threatened wildlife or plant species or critical habitats are known to occur on the site, although concentrations of bald eagles are known to winter along the North Fork Stillaguamish near and downstream of the project area (Appendix D).

Assessment of Impacts. The application of sludge by spraying into and over the Douglas-fir plantation would affect wildlife species in several ways. Some small percentage of the wildlife may come in direct contact with sludge during the actual application of sludge. Some bird species would be particularly vulnerable (nesting birds and the more sedentary bird species such as the winter wren), whereas others could more readily flee the area. Any mortality resulting from spraying activities would be small and would not adversely affect the long-term viability of the wildlife populations.

Other wildlife would be affected by ingestion of sludge during feather preening or fur grooming, or when searching for and consuming food that was sludge-covered. Examples of ingestion might include black-capped chickadees consuming sludge-covered catkins; flickers and downy woodpeckers inadvertently ingesting sludge when searching under bark for insects; shrew-moles ingesting sludge burrowing in leaf litter; black-tailed deer consuming sludge-covered forage; and striped skunks ingesting sludge while rooting in leaf litter and ground cover.

West et al. (1981a) and West et al. in Bledsoe (1981b) studied the impact of sludge application on black-tailed deer and several small mammals at Pack Forest. Some of their findings were as follows:

- Liver and kidney tissue levels of heavy metals were generally higher in small mammals from sludge-treated areas than from control areas; however, no such increases were observed in black-tailed deer.
- High concentrations of cadmium were found in only one species of small mammal.
- Concentrations of cadmium were found to be higher in kidney tissue than liver tissue.
- Lower heavy metal tissue concentrations were found in herbivorous (leaf-eaters) and granivorous (grain-eaters) species than in insectivorous (insect-eating) species.
- Plant species consumed by herbivorous species absorb metals in varying quantities (Table 3-16), but cadmium concentrations in kidneys of herbivores were below those known to be acutely toxic in humans and laboratory animals.

A third possible means of sludge affecting wildlife would be from bioaccumulation: animals consuming lower forms (plants, insects, or other animals) that have accumulated heavy metals.

Evidence to date indicates that bioaccumulation of heavy metals does occur when sludge is applied to land, particularly in insectivores. West et al. (1981a) found cadmium concentrations in the kidney cortex of shrew-moles taken from sludge-amended sites at the Pack Forest to be near the levels known to be physiologically harmful. According to Clark (1979), lead and cadmium accumulate in bats and shrews, possibly because of their high metabolic rate and diet of insects.

Wade, et al. (1982), Helmke et al. (1979) and Beyer et al. (1982) established that earthworms from sludge-amended sites contained significantly more cadmium than did earthworms from control samples. Concentrations of cadmium in earthworms studied by both Helmke et al. (1979) and Beyer et al. (1982) were found to be as high as 100 ppm. No studies have been completed analyzing the effects of earthworm ingestion on higher trophic organisms. Wildlife species that do consume earthworms as a normal part of their diets (e.g., skunks, shrews, moles, passerine birds) could be exposed to large concentrations of cadmium.

Table 3-16. Metal Concentrations ($\tilde{x}$ ± S.D.) in Plant Species Found on Sludge-Treated and Control Areas at Pack Experimental Forest

	Zinc		Copper		Lead		Cadmium	
	Control	Sludge	Control	Sludge	Control	Sludge	Control	Sludge
	Metal content - - - - - μg/g - - - - -							
Salal	22.3 ±5.3	37.0 ±7.8	5.25 ±1.4	4.87 ±1.6	0.6 ±0.3	1.7 ±0.6	0.09 ±0.03	0.43 ±0.38
Fern	19.8 ±4.0	31.8 ±9.0	4.86 ±0.8	6.68 ±2.1	1.5 ±0.6	0.9 ±0.3	0.09 ±0.05	0.15 ±0.09
Oregon grape	26.7 ±6.1	29.5 ±7.3	9.6 ±3.9	9.2 ±4.8	2.2 ±0.4	1.3 ±0.6	0.02 ±0.02	0.06 ±0.02
Blackberry	33.6 ±6.8	56.4 ±15.9	5.94 ±1.2	5.9 ±1.2	1.5 ±0.6	1.2 ±1.0	0.04 ±0.03	0.25 ±0.12
Ocean spray	16.1 ±3.7	33.2 ±9.8	8.87 ±1.0	7.14 ±0.9	4.8 ±1.8	2.6 ±0.6	0.26 ±0.08	1.22 ±0.42
Rose	6.9 ±5.6	22.6 ±8.4	5.6 ±0.8	4.6 ±0.6	2.1 ±0.8	1.9 ±0.3	0.03 ±0.02	0.10 ±0.03
Thistle	29.2 ±10.3	327.5 114.3	10.7 ±0.5	14.3 ±2.4	3.12 ±0.0	1.7 ±0.5	0.19 ±0.02	2.92 ±0.67

SOURCE: West et al. 1981a.

Very little is known about potential chronic toxicity impacts on wildlife or bioaccumulation in the vast majority of wildlife species. More study is required on this subject before conclusions can be reached. Wildlife could also be affected by changes in flora caused by sludge application. West et al. (1981a) found that the growth of some understory plant species was increased by sludge application, and that any shift in plant community structure would alter the species abundance and composition of small animals. Reduced species numbers and abundance on sludge-amended areas were found, and deer use and population density of sludge-amended areas increased (West et al. *in* Bledsoe 1981b).

Some populations of wildlife species may increase in sludge-applied areas in response to the more vigorous growth of understory vegetation. Such population increases have been previously observed at the University of Washington Pack Forest.

In all likelihood, some or all of the above-mentioned impacts would occur at the Pilchuck site. Continued research in this area by the University of Washington should provide greater understanding of many of the currently uncertain impacts.

The U. S. Fish and Wildlife Service (USFWS) (see Appendix D) has identified three major concerns regarding the on the bald eagle which should be considered in evaluating potential impacts of the proposed project:

- Loss of streamside habitat perch sites.
- Disruption of habitat and eagle activity during construction and operation of project facilities.
- Contamination of eagle prey items downstream of the project area.

Because the proposed project would not result in any construction activities near either the North Fork Stillaguamish River or Kunze or Rock Creeks, no streamside habitat loss (i.e., perch sites) would occur. Furthermore, it is judged that since any project construction (sludge storage basins) would be well away from the Stillaguamish River (approximately 1 mile) and project operation would be intermittent and of a short-term nature (7-8 months), neither bald eagle habitat nor bald eagle feeding or perching activities would be adversely affected.

Contamination of any eagle prey species downstream of the project area is a highly unlikely event. Please refer to descriptions of the likely impacts on surface water and aquatic ecosystems as presented in other sections of this EIS.

Mitigation Measures. Metro has proposed that sludge application on the 70-acre site be terminated in mid-March to minimize the impact of sludge application on nesting birds.

Silviculture

Description of Existing Environment. The two sites scheduled to receive the first applications of sludge represent different age phases of a Douglas-fir forest. The southern site contains a stand of 24-year old Douglas-fir. Western hemlock of approximately the same age are scattered throughout the stand. The diameter at breast height (dbh) ranges from 5-18 inches, and total tree height varies from 40-80 feet. Current stocking is about 300 stems per acre, with trees spaced 10-20 feet apart. A commercial thinning (removal of merchantable trees) is planned between 1983 and 1987. The stand is planned for clearcut harvest in 2000.

The northern site contains two Douglas-fir stands. The older of the two stands was planted in 1971 and contains approximately 21 acres near the northern boundary of the site. Grand fir of approximately the same age are scattered throughout. The stand ranges in height from 20-25 feet and has an average dbh of 4 inches. Tree spacing varies between 10 and 12 feet, yielding a stocking rate of 350-400 stems per acre. Basal area (sum of cross sectional areas at breast height of all trees) is about 35 square feet per acre. Two commercial thinnings are planned; the first between 1985 and 1990 and the second between 2000 and 2020. Clearcut harvest is planned between 2015 and 2020 (Staringer pers. comm.).

The younger stand on the northern site covers about 37 acres and was planted in 1976-1977. Tree height ranges between 6 and 12 feet with a dbh between 1.5-2.0 inches. Current spacing is about 6 feet, with a stocking of about 600 stems per acre.

A precommercial thinning (removal of nonmerchantable trees) of both sites is scheduled for the years between 1983 and 1986. Commercial thinnings will take place between 1995 and 2000 and between 2005 and 2010. Final harvest will occur between 2020 and 2025. A complete stand history for both sites is in Appendix C.

Productivity on both sites is limited by nitrogen deficient soils, low moisture holding capacity of the soil, and Swiss Needle Cast. The gravely texture of the soils facilitates rapid water movement through the soil profile which in turn results in low moisture holding capacity and loss of nitrogen. Swiss needle cast (*Phaeocryptopus gaumanni*) is a widespread fungus that attacks mainly young trees. The black fruiting bodies of the fungus block the needles' pores, causing a gradual yellowing and death of the needles. Nearly all trees under the age of 20 years on the demonstration sites show some sign of the disease. The older stand on site 8 was sprayed with the fungicide Bravo 500 in June 1982 to control the fungus.

The two potential sludge application sites possess understory vegetation typical of managed Douglas-fir stands. The closed canopy of the south site prevents direct sunlight from reaching the forest floor, resulting in a sparse cover of understory vegetation. Major species include elderberry, blackberry, sword fern, salmon berry, and some salal.

The southern half of the north site possesses the most dense and diverse understory community of the potential application areas. The open canopy of this young stand permits the growth of salmonberry, blackberry, thimbleberry, and sword and bracken fern. The northern half of the site contains a less dense understory consisting of these same species.

Because understory species retard the growth of newly planted Douglas-fir seedlings, herbicides are commonly applied to Tree Farm stands within 5 years of planting.

Assessment of Impacts.

Timber and Understory Growth -- Application of sludge to forestlands would provide the potential for increasing the growth rates of managed stands. Potential increases in tree growth following sludge application are due primarily to the large influx of nitrogen, which often limits growth on glacial soils. Increases in the water and nutrient holding capacities, the organic matter content, and overall nutrient levels also promote increased tree growth.

The first noticeable change in Douglas-fir stands receiving sludge, is a change in foliage color; from light green to dark greenish-blue. This change usually occurs within 1 year of application (Archie and Smith in Bledsoe 1981; Zasoski et al. 1977). Color changes usually occur in conjunction with increased growth. Although impressive growth increases have often been noted, prediction of a stand's response based on previous studies should be done with caution. Variability in sludge nutrient content, tree species and age, site quality, and sludge application rate influence tree response greatly.

The most comprehensive local research regarding the effects of sludge application on tree growth has been conducted by the University of Washington at the Pack Forest site in western Washington near Mt. Rainier. Although conditions do not match those of the Pilchuck Tree Farm exactly, many site parameters are similar.

Growth responses on the Pilchuck north site may be approximated by the results from a 10-year old Douglas-fir stand on a glaciated site III plot at Pack Forest. One year after receiving 1 inch of Metro sludge, this site recorded a 10 percent height increase and a 58 percent increase in basal area over controls (Henry and Cole 1983). This response seems to be typical of young Douglas-fir stands.

Growth data have not been collected for plots similar in age and site quality to the Pilchuck south site (age 24). Pack Forest research on older stand (50+ years) has shown that those stands also respond to sludge application, especially if the site is of poorer quality (Edmonds and Cole 1982); these authors suggested that the optimum stand age for sludge application is between 5 and 30 years. All trees on the Pilchuck sites are within that age range. Although the longevity of increases in growth rate is not known, Henry and Cole (1983) have found the response to last at least 4 years.

The only negative growth responses in Douglas-fir recorded locally have occurred following very heavy sludge applications or application to extremely dense, young stands (Henry and Cole 1983; Zasoski et al. 1977). The relatively small applications proposed for Pilchuck, coupled with the tree farm's active thinning policy, should prevent any negative growth responses following sludge application.

No quantitative data are available concerning the growth of understory species following sludge application. Large but variable rates of sludge application have resulted in reduced growth of salal and Oregon grape (Edmonds and Cole 1976). Smaller sludge applications have produced positive growth responses in some species (West et al. 1981a).

Application of sludge to the Pilchuck sites would not cause a change in the management of the sites. Following stand harvest and subsequent planting, those sites would be treated with a herbicide regardless of sludge application plans (Staringer pers. comm.).

Metal Uptake -- Research has been conducted concerning possible increases in heavy metal uptake by trees following sludge application. Increases in the foliar heavy metal content of Douglas-fir seedlings grown for 1 year in a sludge/soil mix were noted only for zinc (Bledsoe and Zasoski in Bledsoe 1981). Limited data from sludge application to older Douglas-fir stands revealed slight increases in foliar concentrations of copper and zinc (Zasoski et al. 1977). Cadmium, chromium and nickel concentrations in that study remained below one ppm.

Wood Quality -- Potential sludge-induced tree growth increases may result in a change in the anatomical properties of the wood. Research on this subject is still in the early stages. Preliminary indications are that trees may experience a slight drop in specific gravity (related to wood strength) but experience no change in fibril angle (an indicator of overall wood quality) (Leney and Briggs pers. comm.).

Wood property changes associated with growth acceleration resulting from the application of conventional fertilizers are well documented. Erickson and Lambert (1958) measured an 8 percent decline in the specific gravity of wood from a 30-year old Douglas-fir stand that had experienced 22 percent increase in diameter growth following applications of a nitrogen fertilizer.

Mitigation Measures. None required.

Aquatic Ecosystems

Description of Existing Environment. Three streams, Rock Creek, Kunze Creek and the North Fork Stillaguamish River border the proposed application sites on the east, west and south, respectively. Rock Creek and Kunze Creek were surveyed during February and June 1982. Rock Creek is characterized by a steep gradient comprised of mostly rubble and boulders with few large pools and overhanging banks. Results of fish surveys indicated three age classes of cutthroat trout, and juvenile and smolt coho salmon. Large numbers of juvenile salmon were seen along the entire length during the June survey (Metro 1983d). A previous spawning survey conducted by the Washington Department of Fisheries indicated coho spawning between the mouth and river mile 1.5.

Kunze Creek is characterized by a low to moderate stream gradient in the upper portions of the creek, and a steep, rocky gradient at the lower reach. Fish electroshocking surveys in February yielded low numbers of coho salmon and cutthroat trout but like Rock Creek, greater numbers were found during the June survey.

Although no steelhead trout were found during the surveys, as a general rule, steelhead utilize small feeder streams similar to Rock and Kunze Creeks.

The North Fork Stillaguamish River, immediately south of the site, is recognized as an important waterway for anadromous fish. Eight anadromous species are known to utilize the North Fork and its tributaries.

Assessment of Impacts. As discussed in the surface water evaluation of the Pilchuck project, surface water contamination from sludge runoff is not likely to be a significant problem. Therefore, aquatic resources are not likely to be affected by sludge runoff.

In the event sludge were to enter either Kunze or Rock Creeks the impact on fish would depend on such factors as the time of the year, water temperature and dissolved oxygen (DO) content, stream flow, BOD and quantity of the sludge, dilution and dispersion of the sludge in the creek. Upper Kunze

Creek would probably represent the portion of the two creeks most vulnerable to the impact of a small sludge spill (accidental spraying of sludge into the creek).

In the unlikely event of a large spill on Kunze Creek, a majority of the fish and invertebrate populations in the affected portion of the creek would probably be killed off because of the high BOD and subsequent lowering of dissolved oxygen and physical smothering.

If a small sludge spill should occur, the resultant impact would depend on the factors mentioned earlier in this impacts discussion. The worst-case situation likely would be when stream flows are lowest and water temperatures are highest (September or early October), or when eggs had been deposited. Fish embryonic and larval stages are especially vulnerable to reduced DO concentrations (EPA 1976b).

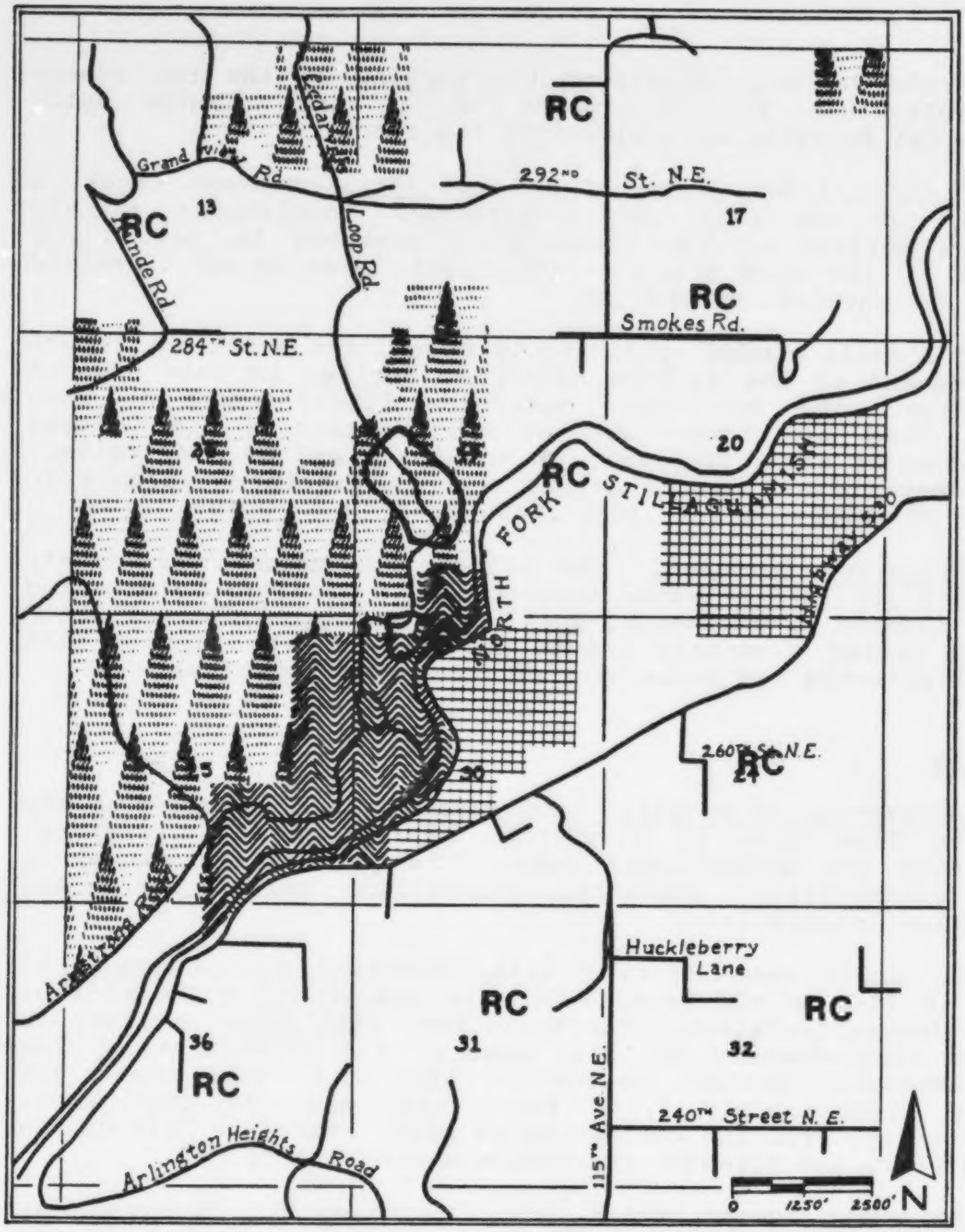
Mitigation Measures. The mitigation measures previously described for surface water impacts should assist in minimizing the likelihood of accidental spills. In addition, stream water quality tested bimonthly should be analyzed in terms of EPA (1976b) criteria for protection of freshwater organisms.

Land Use

Description of Existing Environment. Land surrounding the Pilchuck Tree Farm is a mixture of residential, forestry, recreation and agricultural uses. The predominant zoning is rural conservation, forestry, agriculture and forestry and recreation (Figure 3-6).

The south demonstration site, covering approximately 15 acres of 24-year old Douglas-fir, is completely surrounded by closed-forest landscape. The North Fork Stillaguamish River is located approximately 200 feet east of the demonstration site and Cottonwood Terrace recreation area and Kunze Creek are located approximately 3,500 feet south and 200 feet west, respectively, from the demonstration site. The site lies within the forestry and forestry-recreation zoning districts.

The north demonstration site, approximately 55 acres, is bounded by forest and Rock Creek on the east, forest on the south, forest and Kunze Creek on the west and forest and residential development on the north. The 11-lot residential development approximately 500 feet north of the demonstration site was established in 1979 and currently has eight single-family and mobile home dwelling units. The north site is covered by Douglas-fir and grand fir trees, and lies within the forestry zoning districts.


RC
13
Grand View Rd.
Cedar
Loop Rd.
292ND St. N.E.
17
RC
Lunde Rd
RC
Smokes Rd.
284TH St. N.E.
20
RC
NORTH FORK STILLAGUAMISH
25
30
260TH St. N.E.
RC
Armstrong Rd
Huckleberry Lane
RC
RC
36
31
32
RC
115TH Ave N.E.
240TH Street N.E.
Arlington Heights Road
0
1250'
2500'
N

SOURCE: SNOHOMISH COUNTY, 1982

FIGURE 3-6
Zoning in the Project Vicinity

legend
RC RURAL CONSERVATION
▦ AGRICULTURE 10 ACRE
▨ FORESTRY AND RECREATION
▲ FORESTRY

All three alternative sludge handling facilities and equipment storage areas are completely bounded by forest vegetation. The zoning in these areas is either forestry or forestry-recreation, depending upon exact location of the facilities.

Land Use Plans and Policies -- A number of subregional, county and municipal plans and policies affect future land use in the Pilchuck Tree Farm area. The Snohomish Subregional Development Plan is a comprehensive growth management strategy for the development of the Snohomish subregion. This plan contains broad goals and policies covering three major issues currently facing the subregion; activity centers, housing and public services (PSCOG 1979).

The Snohomish County Shoreline Management Master Program (September 1974) is comprehensive plan for the effective management of shoreline resources. The plan contains goals and policies, use regulations, and maps which regulate various activities and development within the shoreline. The shoreline is generally defined as the area within 200 feet of the high water level including the entire floodplain and associated wetland of a waterbody.

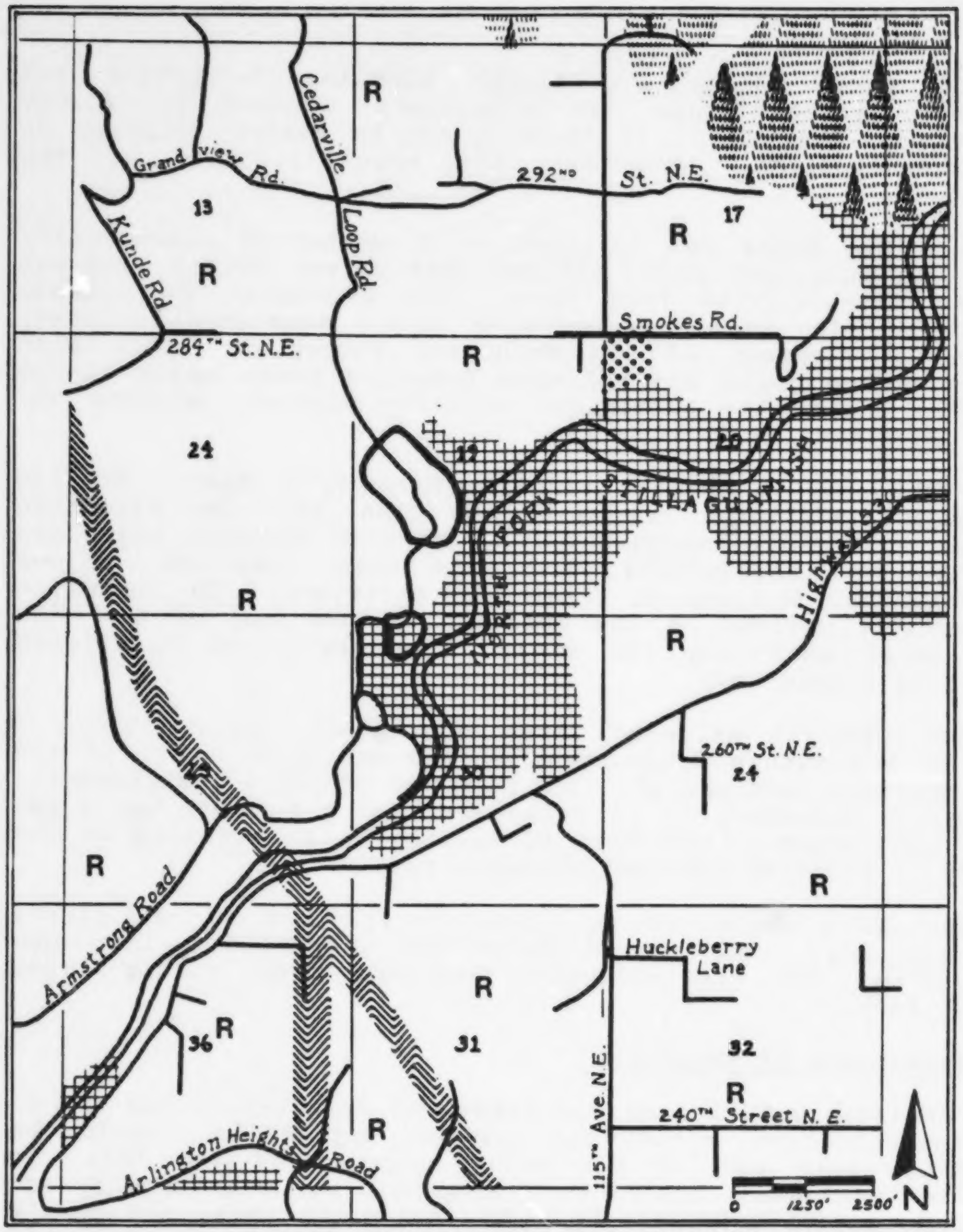
The County's Arlington Area Plan (AAP) (March 1975), a guide to the future development of the Arlington area, is the most important land use plan for purposes of project assessment. The plan's objective is to perpetuate and reinforce the rural county environment. The City of Arlington is presently in the process of updating its comprehensive plan.

The AAP's goals and policies are included in the plan's land use map. The map depicts the recommended land use designations for the Arlington planning area through 1990 (Figure 3-7).

Assessment of Impacts.

Consistency With Land Use Plans and Policies -- The use of the demonstration sites for sludge application would be consistent with one of the major purposes of the AAP: to reinforce management practices which would protect forestry and timber long-term productivity. To accomplish this, the plan's policies deal with using forest management methods that sustain high yields, provide multiple uses of the forest, and are in accordance with sound economic, ecological, and land use planning principles.

Demonstrations at Pack Forest near Eatonville, Washington have shown that tree growth increases significantly after sludge application. In the long-run, sludge application to forestland would help to sustain yields and consequently the forest economy of the county.


R
Cedarville
Loop Rd.
Grand view Rd.
292ND St. N.E.
13
17
Kunde Rd
284TH St. N.E.
Smokes Rd.
24
19
20
North Fork Stillaguamish
Highway 530
260TH St. N.E.
24
27
Armstrong Road
Huckleberry Lane
36
31
32
115TH Ave. N.E.
240TH Street N.E.
Arlington Heights Road
0
1250'
2500'
N

SOURCE: ARLINGTON AREA PLAN, SNOHOMISH COUNTY, 1975

FIGURE 3-7
Projected
1990 Land Uses

legend

R	RURAL (.2-.4 DU/A)
▨	PARK/OPEN SPACE
⊞	AGRICULTURE (1DU/10A)
⁘	COMMUNITY FACILITIES/SCHOOLS
▲	FORESTRY

The application of sludge to forestland would be consistent with the plan's policies of using innovative methods of waste disposal and conducting short-term uses of land for waste disposal in such a manner that public benefits are maximized, while detrimental effects on the environment are minimized.

The 12-month Pilchuck demonstration project is an innovative method in sludge disposal. These demonstration sites have been selected because of their relatively isolated locations and potential for limited environmental problems. The sites would be monitored for environmental effects during and after the sludge application.

Direct and Indirect Land Use Changes -- The demonstration project would not change the land uses on the tree farm or in the surrounding area in the short run. The application of sludge to forests would enhance the forest growth by providing a source of nutrients.

Concern has been expressed by the Pilchuck Citizens Advisory Committee that if land uses on the tree farm or in the area change, the new land owners and/or residents could possibly not know of the sludge application. In response to this concern the tree farm will amend its county land records to describe the actual sites of sludge application, amounts, dates of application, and concentration of heavy metals in the sludge applied. Any title search connected with property within the tree farm would contain a reference to sludge amendments.

The proposed application rate of 20 dry tons/acre would result in a cadmium loading of 2.0 pounds/acre (2.2 kg/ha). Based on EPA regulations (40 CFR Part 257) at that rate, the application sites could be used in future years for production of food chain crops so long as the soil pH was adjusted to 6.5 or greater whenever crops were grown. The project would therefore not preclude any future uses of the site, even for the most restrictive use - production of food chain leafy vegetables.

Property values surrounding the tree farm are not expected to decrease as a result of the sludge application either in the short or long-run. The Snohomish County Assessor's Office has provided a written opinion to the tree farm that property values are unlikely to be affected by the demonstration (Pilchuck Citizen's Advisory Committee minutes October 1982).

Mitigation Measures. Based on initial results of spray application operations the buffer zone between the residences and the north demonstration site could be increased to provide additional protection from potential odors, noise, and aesthetic changes.

Population and Housing

Description of Existing Environment.

Existing Population and Recent Trends -- According to U. S. Census data, the 1980 population of Snohomish County was 337,720. The population growth rate in Snohomish County between 1970 and 1980 was approximately 27.3 percent. The unincorporated areas grew at a considerably higher rate (45.9 percent) than did the incorporated areas (10 percent).

For the purposes of this impact analysis, population growth in sections 13, 24, 25 and 36 (T32N, R5E) and sections 17 through 20 and 29 through 32 (T32N, R6E) was evaluated. This study area is within census tracts 534 and 535.02 (See Figure 3-8). Table 3-17 indicates the population changes in census tracts 534 and 535.02 from 1970 to 1980. The population increase in tracts 534 and 535.02 can be partially attributed to people wanting to live in a rural setting and moving out of the local communities. Census tract 535.01, which is not directly in the study area, predominately covers the City of Arlington. Since 1970, tract 535.01 has grown by approximately 30.2 percent. The City of Arlington has grown rapidly over the last 10 years, from a population of 2,261-3,282. The 1979 median family income level of residents was $21,193 in tract 534 and $17,791 in tract 535.02 (Cost pers. comm.).

Projected Populations -- Snohomish County is projected to increase in population from 337,720 in 1980 to 430,452 in 1990 and to 533,388 in 2000. The project study area is projected to grow from 6,731 in 1980 to 8,951 in 1990 and to 10,467 in 2000 (Cost pers. comm.).

The 1975 Arlington Area Plan projects that the Arlington planning area, which includes the project study area, will grow at a slightly higher rate between 1980 and 1990 than will Snohomish County as a whole. The Arlington planning area is expected to grow by 38 percent, and the county by 34.3 percent. Most of the growth in the Arlington planning area will likely occur in the vicinity of the Arlington airport (Arlington Area Plan 1975; Newman pers. comm.).

Existing Housing Conditions and Recent Trends -- According to the 1980 census, Snohomish County had 131,206 dwelling units. Of this total, 40,410 new dwelling units were built between 1970 and 1980. Census tracts 534 and 535 had 1,755 new dwelling units from 1970-1980. This number represents dwelling units constructed within the 1970 census tract boundaries. The City of Arlington's housing stock increased by 474 dwelling units from 1970-1980.

Housing in the study area is generally sparsely scattered and on lots of 2.3 acres or larger. In 1979, a large tract survey (section 24, T32N, R5E) was created just northwest of the

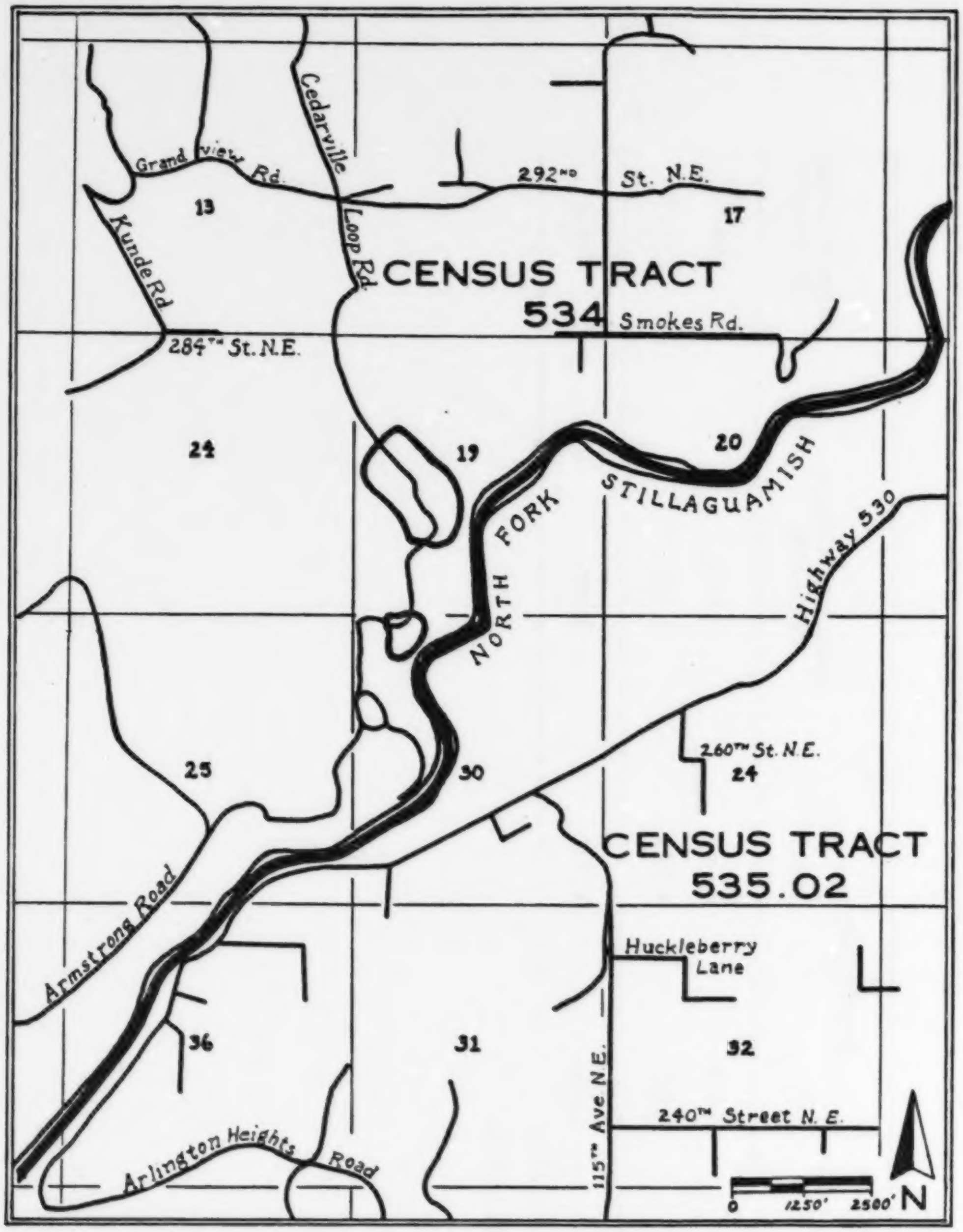

Grand view Rd.
Cedarville Loop Rd.
292ND St. N.E.
13
17
Kunde Rd
CENSUS TRACT 534
Smokes Rd.
284TH St. N.E.
24
19
20
NORTH FORK STILLAGUAMISH
Highway 530
25
30
260TH St. N.E.
24
CENSUS TRACT 535.02
Armstrong Road
Huckleberry Lane
36
31
32
115TH Ave N.E.
240TH Street N.E.
Arlington Heights Road
0
1250'
2500'
N

FIGURE 3-8
Census Tracts in the Vicinity of the Pilchuck Tree Farm

Table 3-17. Population Changes from 1970 to 1980 in Census Tracts in the Vicinity of the Pilchuck Tree Farm.

Census Tract	Population		Numerical Change 1970-1980	Recent Change 1970-1980
	1970	1980		
534	1,439	2,288	849	59
535.02	2,247	4,443	2,196	97.7
TOTAL	3,686	6,731	3,045	82.6

SOURCE: Cost pers. comm.

1983 proposed sludge application site. The survey created 11 lots varying in size from approximately 5-6 acres. At the present time, there are eight dwelling units located in this large tract survey.

From 1979 to 1981, there were no new recorded plats in the study area. During this same time period, only five new short plats were recorded by the county. These five short plats created 12 new lots.

In 1979, 13 new dwelling units, including single-family and mobile homes, were constructed in the project area. Twelve new dwelling units were built in the project area in 1980. And in 1981, 14 new dwelling units were constructed, the approximate locations of these new dwelling units are shown in Figure 3-9 (Cost and Newman pers. comm.).

Assessment of Impacts.

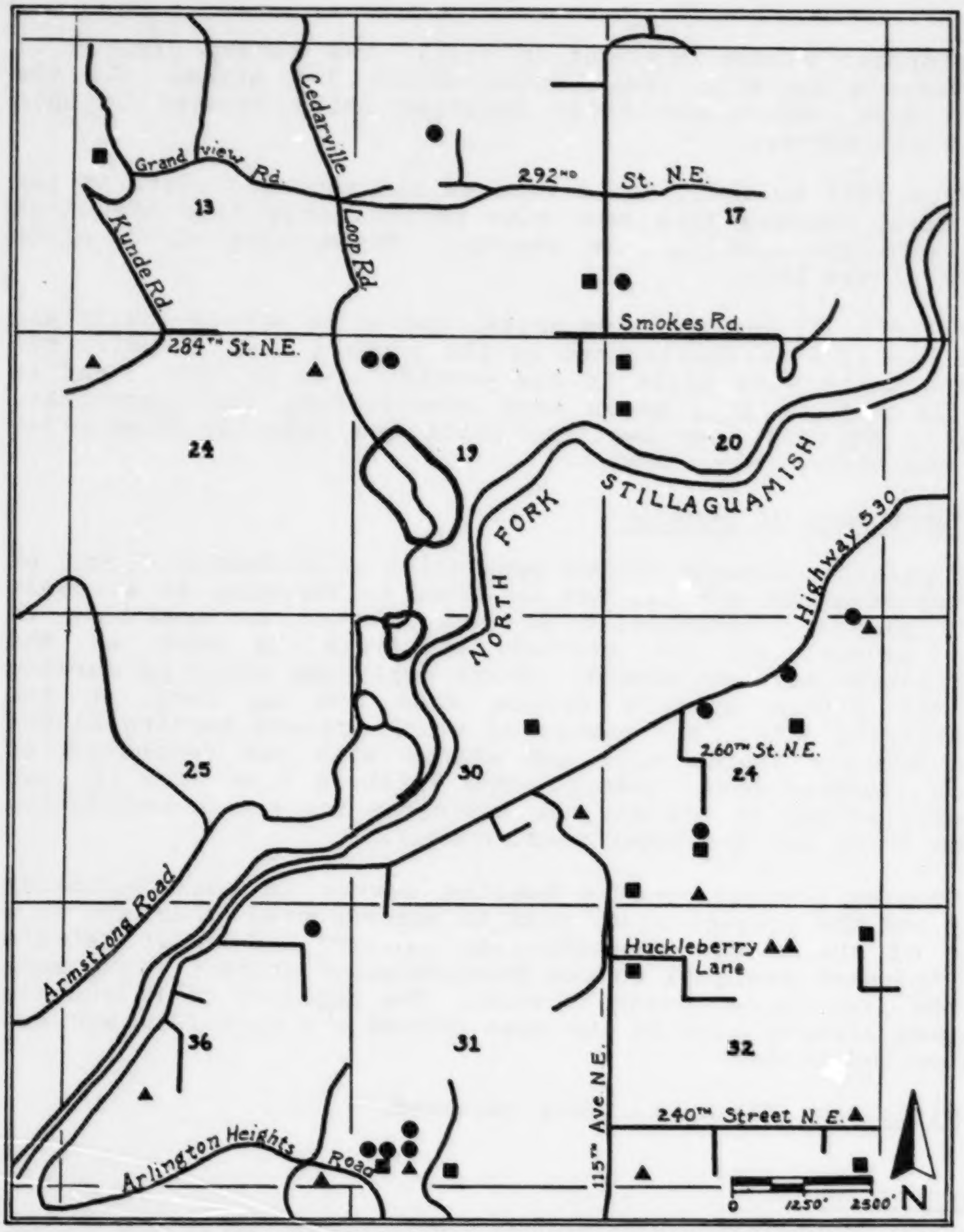
Population Changes -- The population of Snohomish County or the project study area is not expected to increase as a result of the sludge demonstration project. Metro is expecting to assign several of its current employees to work at the demonstration site as needed. These employees would be working elsewhere within Metro's system when not on duty at the demonstration site. The number of truck drivers hauling sludge within Metro's system will not change with the demonstration project (Cochran pers. comm.). The Pilchuck Tree Farm is also not anticipating to add any new employees for the demonstration project (Rice and Staringer pers. comm.).

Housing Changes -- The housing market in both Snohomish County and the project study area is not expected to change as a result of the sludge demonstration project. Some of Metro's four employees assigned to the demonstration project might move into the area to be closer to work. The majority of Pilchuck's employees already live in the area around the tree farm and are not expected to move.

Mitigation Measures. None required.

Transportation

Description of Existing Environment. The estimated sludge hauling distance from Metro's West Point Treatment Plant to the storage lagoons on the Pilchuck Tree Farm would be 70 miles each way. The proposed haul route from the treatment plant would be through Discovery Park to Interstate 5 and north on Interstate 5 to the State Route 530 exit. Trucks would then travel east on 530 to Arlington, and then north on State Route 9. The 1981 average daily traffic (ADT) for State Route 530 was 5,400 vehicles, and State Route 9 ADT was 2,500 vehicles (Metro 1983d).


Grand view Rd.
Cedarville Loop Rd.
292nd St. N.E.
Kunde Rd
284th St. N.E.
Smokes Rd.
NORTH FORK STILLAGUAMISH
Highway 530
260th St. N.E.
Armstrong Road
Huckleberry Lane
115th Ave N.E.
240th Street N.E.
Arlington Heights Road
13
17
24
19
20
25
30
24
36
31
32
0
1250'
2500'
N

SOURCE: SNOHOMISH COUNTY PLANNING DEPARTMENT, 1982

FIGURE 3-9

New Residential Development in the Project Vicinity

legend

■ NEW RESIDENTIAL DEVELOPMENT 1981

▲ NEW RESIDENTIAL DEVELOPMENT 1980

● NEW RESIDENTIAL DEVELOPMENT 1979

After traveling 1.4 miles on State Route 9, trucks would turn right on Armstrong Road, a 20-foot wide gravel road which serves residents of the Lake Armstrong area. Traffic on Armstrong Road is partially controlled by an advance warning flashing light system for eastbound traffic. Because of the narrow roadway, eastbound traffic must pull to the side of the roadway to allow westbound traffic to pass.

Trucks leaving the Pilchuck site would not return State Route 9 via Armstrong Road, but would instead return via Brakken Road and Grandview Road. Both roads are paved, with stop signs located at the intersection of Brakken and Grandview Road and the intersection of Grandview Road and State Route 9. Trucks entering onto the State Route 9 would travel south to Arlington and return to Interstate 5 via State Route 530.

Land use along State Route 530 is primarily agricultural with scattered areas of commercial uses (at the Interstate 5/530 interchange and within the Arlington City limits). Land use along State Route 9 and Armstrong Road is predominately agricultural and forestry.

Assessment of Impacts. Sludge handling to the Pikchuck Tree Farm during the summer months would call for 365-520 total truck loads, with 4-9 trucks per day traveling on the proposed haul route. Because daily sludge production at the West Point Treatment Plant is greater during the winter months, more truck trips could be scheduled per day (14-19 trucks per day) with hauling to occur for a shorter period of time (15-20 days).

To avoid potential conflicts with school busing activities, the Pilchuck Citizen's Advisory Committee has recommended that no hauling be carried out Mondays through Fridays during the hours of 7-9 in the morning and 3-5:30 in the evening (September through June). During the remaining 19.5 hours of hauling time, the number of trucks could vary from 1 truck per hour to 1 truck per 2 hours depending on the amount of sludge generated each day.

The projected number of daily truck trips would have no measurable impact on either State Route 530 or State Route 9 capacities, contributing only an additional 18-38 daily trips for each roadway.

Any traffic congestion problems in Arlington or on Armstrong Road that might be caused by sludge hauling trucks would be reduced by the limitations set on sludge hauling during the school busing hours. The school busing hours also correspond to the peak work commuting hours and the peak hours of traffic congestion. During the remaining daylight hours and at night, the traffic volume on Armstrong Road is expected to be lower than during the peak hours. When sludge hauling would be most frequent, some traffic delays on Armstrong Road may occur, however, because of the narrow width of the roadway.

Because both State Route 530 and State Route 9 are asphalt/concrete roadways in good condition, and designed to handle heavy truck loads, sludge hauling would not be expected to cause inordinate roadway deterioration. The Armstrong Road would be more susceptible to deterioration since it is a gravel surface road. Deterioration would most likely occur at curves in the road when gravel is pushed to either side as a result of traffic movement. Deterioration would also occur during the winter months, particularly during and after heavy rains.

Trucks leaving Pilchuck Tree Farm would stop for gate openings and closure just prior to exiting onto Brakken Road. Noise from air and throttle brakes, engine idling, and exceleration would occur at that location as well as at the Brakken-Grandview Road and Grandview-Route 9 intersection. Some residents of the approximately 20 homes along Brakken and Grandview Road would be affected by the truck traffic, particularly during the nighttime hours. Depending on the frequency interval of truck traffic, some minor traffic merging delays may occur at the intersection of Grandview Road and State Route 9.

Mitigation Measures. The peak hour limitation proposed by the Pilchuck Citizen's Advisory Committee would significantly reduce the potential for congestion, delays and accidents, since trucking would not be carried out when local traffic volumes are the greatest.

The following measures should also be considered for the Armstrong Road area:

- Improve the advance warning signaling device to ensure that if functions efficiently and properly. The warning signal at present does not always operate when traffic is present (Pilchuck Advisory Committee pers. comm.).
- Road signs should be erected on Armstrong Road warning motorists of wide-load vehicle use of the road.
- Metro should coordinate with Snohomish County to establish periodic cooperative maintenance checks and repairs to Armstrong Road.

Aesthetics

Description of Existing Environment. The south demonstration site is surrounded by a closed-forest landscape of dense conifers. A few logging access roads are scattered throughout the site and surrounding forest. This site is not readily visible from either the Stillaguamish River, some 200 feet east of the site, or any other area of Pilchuck Tree Farm.

The north demonstration site, located approximately 500 feet from the tree farm's northern property boundary, is surrounded by conifers and deciduous stands of various ages.

The northern boundary of the site is bounded by approximately 300 feet of Douglas-fir and grand fir trees planted in 1971, with an average overall height of 20-25 feet, and 200 feet of Douglas-fir trees planted in 1979, with an average overall height of 2-3 feet. Surrounding the site on the eastern, western, and southern boundaries are coniferous and deciduous heights and density. This site is currently partially visible trees of various ages, from the residences located north of the Pilchuck Tree Farm boundary.

There are four alternative sludge handling facilities and equipment storage areas proposed for the demonstration project. The first two alternatives, a 1 mg basin or a smaller storage basin, would be located near the BPA transmission line that runs north and south through the tree farm. This cleared area, surrounded by closed-forest landscape is completely isolated within the tree farm. A logging access road is parallel to the transmission line.

The third alternative would involve locating long-haul trucks, storage tanks, and application vehicles near the application sites. Equipment stored near demonstration sites would be surrounded by forest vegetation of various ages, heights, type and density. The equipment would not generally be visible to anyone except sludge workers and tree farm employees.

Under the fourth alternative, long haul trucks would be used to store sludge before it is transferred to the application vehicle. No site location has been determined yet.

The most perceptible odor associated with demonstration sites is from the forest itself. The perception of this forest-earthy odor varies accordingly to individual's sensitivities as to whether it is pleasant or not.

The level of noise associated with the demonstration sites varies depending upon time of the year. In the spring and summer seasons, motorcycles and other loud off-road vehicles frequently use the logging access roads. Certain noises from normal routine tree farm activities such as insecticide spraying, thinning, and harvesting can also be heard during this time. Generally, there is little noise heard during the fall and winter seasons except for a brief period during hunting season.

Light and glare are not currently emitted from the demonstration sites.

Assessment of Impacts. During the operational phase, sludge would be sprayed onto the conifers, coating either the foliage or the tree bark and understory vegetation with a grayish black material that resembles used crankcase oil in appearance. As the sludge dries, it turns a lighter-gray color and forms flakes on the needles and understory vegetation. The sludge would remain on the conifers and understory vegetation until it is washed off by rains. During the time period from the initial sludge spraying to when the rains have removed the sludge, the forest's visual quality would be significantly altered. After rains remove the sludge, the forest appearance would return to normal. Based on results at Pack Forest, a majority of the applied sludge was not visually evident 2 months following application.

A few months after sludge application, the forest appearance would change to a darker, richer green color and would often appear healthier and more vibrant. The richer forest color will remain for many years thereafter.

Long-haul trucks carrying sludge to the demonstration sites, over state highways, county and city roads, and logging access roads would not adversely impact the aesthetics of these roadways unless an accident were to occur with sludge being spilled.

A distinctive odor would be associated with the operational phase of the demonstration. The odor would come from the handling facilities, equipment storage areas, and the spraying of sludge onto the demonstration sites. The reaction to the odor of sludge differs according to individual sensitivities. Some people find the odor to be musty, barnyard-like, pleasant or noxious. The odor associated with sludge application was one of the 17 concerns expressed by the Pilchuck Citizen's Advisory Committee. The odor of sludge would generally be most pronounced when a large surface area of sludge was exposed to air, such as during spraying operations. After application, the odor would abate and essentially cease as the thin layer of sludge becomes aerobic (Pilchuck Citizen's Advisory Committee minutes October 1982).

Noise associated with the operational phase would come from loading, unloading, pumping, and transferring sludge from the long-haul trucks to the handling facilities and then to the application vehicles. A certain level of noise would also result from the spraying of sludge onto the forest.

Transportation noise from the long-haul trucks transporting sludge from West Point to the demonstration sites would increase significantly along the haul route and in the vicinity of the demonstration site. Hauling of sludge would take place on a round-the-clock schedule with 4-9 trucks per day (2-3 times a night) entering the demonstration sites (Metro 1983d).

Light and glare would be produced from the long-haul trucks' headlights during late night and early morning sludge deliveries. This would create an intermittent nuisance to residents along the haul route.

The adverse aesthetics, odor, noise, light and glare effects from the south site would generally not affect anyone except sludge workers and tree farm workers because of the isolated location and closed-forest landscape of the demonstration site. Summer residents of Cottonwood Terrace recreation area, south of the demonstration site, would possibly be able to detect sludge odors and noises depending upon prevailing climatic conditions.

The adverse aesthetic, odor, and noise effects from the north site may also affect residents living north of the demonstration site, because of the relatively close proximity of the site. Those residents may be able to clearly detect sludge odors and noises but are unlikely to see sludge application vehicles, light and glare, and the sprayed forest.

Residents living along the haul route would experience additional traffic, additional noise, and perhaps some minor sludge odors, as the long-haul trucks passed by.

Mitigation Measures.

- Sludge odor drift will be reduced by spraying the sludge onto the forest on calm days.
- Noise impacts from construction and operation activities may be reduced by restricting the use of heavy equipment to daytime hours, between 8 a.m. and 4 p.m.
- By increasing the buffer zone on the northern boundary of the north demonstration site, aesthetics and odor impacts on residents to the north may be reduced.

Recreation and Access

Description of Existing Environment. The Pilchuck Tree Farm is used for both passive and active recreational activities including motorcycling, horseback riding, berry and mushroom picking, bird watching, hiking, bow hunting, fishing and Christmas tree cutting. The tree farm has a fairly open policy on allowing people to use the land for recreational pursuits (Rice pers. comm.).

The Stillaguamish River, east of the demonstration sites, is used for fishing, swimming and boating. Kunze Creek and Rock Creek, which border the north site, contain small cutthroat and coho salmon but are not readily accessible for fishing.

Southeast of south site is the Cottonwood Terrace recreation area. This 6.7-acre site has approximately 26 lots with mobile homes occupied by elderly and retired people. The lots are leased from the tree farm on a 20-year basis, with the current lease expiring in 2002 (Rice pers. comm.). The tree farm in 1973 dredged a small lake, locally named Schloman Lake, for use by the residents of Cottonwood Terrace (Rice pers. comm.).

Assessment of Impacts. The demonstration sites, and sludge handling facilities and equipment storage areas, would be closed to recreationists during the operational phases of the demonstration and for a 12-month period following the demonstration. The closure of these areas, and the potential loss of recreational opportunities on the tree farm from sludge application, was one of 17 concerns developed by the Pilchuck Citizen's Advisory Committee. The amount of land closed by the demonstration would constitute less than 10 percent of the Armstrong Tract and less than 1 percent of the entire tree farm (Pilchuck Citizen's Advisory Committee Minutes October 1982). This small amount of land being closed would not significantly affect overall recreation opportunities on the tree farm.

Closing of the sludge application area would reduce any potential adverse effect to recreationists in the short term. However, potential long-term effects of allowing recreationists to use sludge-amended land at some future time are not well documented. Potential concerns include recreational berry and mushroom picking, hunting, and fishing. There has been very little research done on the potential human health problems associated with the consumption of berries and mushrooms grown on sludge amended land; however, studies proposed for the Pilchuck project should provide more information on those concerns.

Recreational opportunities at the Cottonwood Terrace recreation area or on the North Fork Stillaguamish River would not be adversely affected by the demonstration because of the 200-foot buffer zone and the 0.75-mile distance from the demonstration area to Cottonwood Terrace.

Mitigation Measures. The area surrounding demonstration sites and the sludge handling facilities and equipment storage areas should be posted to prohibit use, as suggested by the Pilchuck Citizen's Advisory Committee. The committee also suggested that graphic or pictorial warning signs for children be attached to each sign. Local residents should be notified by letter that certain areas of the tree farm are going to be closed for future recreational use until further notice.

Cultural Resources

Appendix E of this EIS presents correspondence with the State of Washington Office of Archaeology and Historic Preservation regarding need for a cultural resources survey of the proposed sludge lagoon site and sludge application areas. The University of Washington Office of Public Archaeology is in the process of conducting appropriate site surveys, which will be completed for the Draft EIS.

Public Health

Description of Existing Environment. A considerable amount of study of the health effects of sludge application, handling and beneficial reuse has been completed since the early 1970s. Particular attention has been given to the effects of sludge on production of food chain crops and production of crops for use as animal feed. Results of many of these studies have been presented in the earlier portion of Chapter 3 and in Appendix A of this EIS.

Assessment of Impacts. The application of sludge to forestland would result in exposure of site workers and others in the area to miciobial pathogens, heavy metals and organic chemicals. Transmission routes from the environment to humans typically may involve: inhalation of aerosols, ingestion or physical contact with contaminated groundwater or surface water, ingestion of contaminated plants or animals or soil by children, and physical contact with sludge handling or a contaminated area.

Microbial Pathogens -- Microbial pathogens found in sludge include bacteria, viruses and parasites. Figure 3-10 shows the possible microbial transmission routes from forest application to humans. Aerosols are typically transmitted to humans by inhalation, ingestion, or deposition in the throat or lungs. Types of bacteria found in Metro sludge include total coliforms, fecal coliforms, fecal streptococcus, salmonellae, shingella and Yersinia (Metro 1983c). A detailed description of each of these bacteria and their occurrence in sludge is found in Appendix A.

Several major factors affect the survival of enteric bacteria: moisture content and moisture holding capacity of the soil; soil temperature; soil pH; sludge organic matter; antagonism from soil microflora, especially actinomycetes; and sunlight (Sagik et al. in Bitton et al. 1980).

In general, bacteria does not survive well in dry, warm soils with high levels of competing biota and pH below 6.5. Higher bacteria die-off rates occur in soils exposed to sunlight than occur in shaded soils. The role of organic matter in bacteria survival is not entirely known; Mullmann and Litsky (1951) indicated that organic content from sludge enhances bacteria survival whereas Van Donsel et al. (1967) indicated that organic matter plays only a minor role when compared to other factors. Temperature, moisture and organic nutrients in proper environmental conditions may stimulate salmonella and shigella bacteria growth after the initial die-off (Akin et al. in Sagik and Sorber 1978).

The exact length of time bacteria survive in the soil after sludge application is not known. Research at a sludge disposal site operated by the East Bay Municipal Utility District in Solano County, California, found significant numbers of total and fecal coliform, fecal streptococci, salmonellae and

Figure 3-10. Possible Pathways of Microbial Transport Out of Sludge in a Silviculture Application

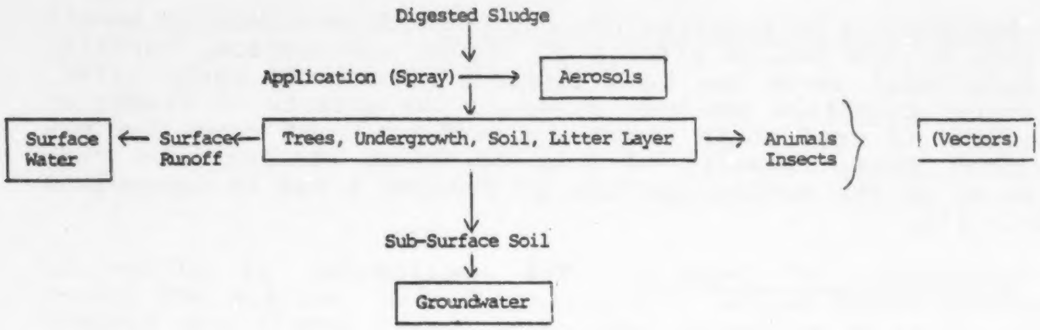

Digested Sludge
Application (Spray)
Aerosols
Surface Water
Surface Runoff
Trees, Undergrowth, Soil, Litter Layer
Animals
Insects
(Vectors)
Sub-Surface Soil
Groundwater

Figure 3-11 Pathways of Metals Transport From Sludge in a Silvicultural Application

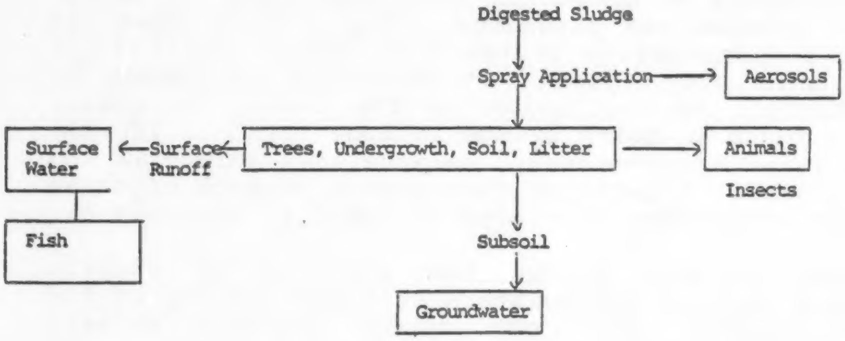
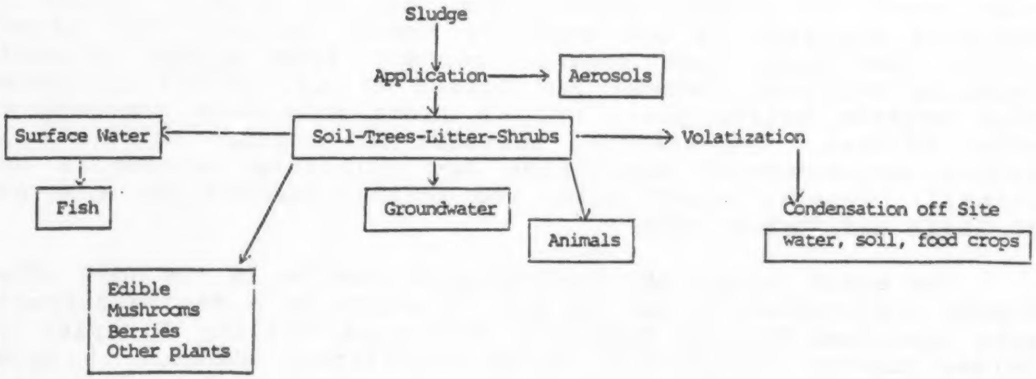

Digested Sludge
Spray Application
Aerosols
Surface Water
Surface Runoff
Trees, Undergrowth, Soil, Litter
Animals
Insects
Fish
Subsoil
Groundwater

Figure 3-12 Pathways for Organic Toxicant Transport From Sludge to Environmental Compartments in Silviculture Application


Sludge
Application
Aerosols
Surface Water
Soil-Trees-Litter-Shrubs
Volatization
Fish
Groundwater
Animals
Condensation off Site
water, soil, food crops
Edible
Mushrooms
Berries
Other plants

SOURCE: Metro 1982c.

shigellae up to 7 months after sludge application to row crop test plots and irrigated and dryland pastures. Certain bacteria species, such as mycobacteria, have survived for long periods in the soil (150 days to 15 months) even under dry environmental conditions (Sagik et al. in Bitton et al. 1980). Experiments at Pack Forest, near Eatonville, Washington, found that the initial die-off of fecal coliform bacteria was rapid and only about 1 percent survived after 45 days. According to Edmonds (in Sopper and Kerr 1979), the bacterial after-growth survival rate in forest applications is 1 percent after 225 days. The bacterial survival pattern apparently follows a declining cyclical series of die-offs and after growths (Sopper and Kerr 1977).

The levels of bacteria concentrations normally required to cause infection and diseases in humans vary with bacteria species and human health conditions. However, generally large numbers of these organism are required to cause infection (see Table 3-18 for an example using salmonellosis).

A variety of viruses may be found in sludge including polioviruses, coxsackie viruses A and B, echoviruses, adenoviruses, and reoviruses. During Metro's intensive sludge monitoring study a mean of 69 enteric viruses per 100 g (wet weight) of West Point undigested sludge were isolated. After anaerobic digestion the concentration of enteric viruses was reduced to a mean of nine viruses per 100 g (wet weight). Calculations based on the total volume of sludge treated indicated a 98 percent reduction of viruses during anaerobic digestion and dewatering (Metro unpublished data).

Survival of viruses in soils is influenced by many of the same factors that affect bacteria, although little direct evidence supports viral inactivation by antagonistic microorganisms (Sagik et al. in Bitton et al. 1980). The ability of viruses to be adsorbed onto solids in the soil also influences survival rates (Metro Sludge Intensive Monitoring Report 1982). Bagdasarjan (1964) working with a wide variety of human enteroviruses, including polio viruses, coxsackie viruses, and echo viruses, reported survival times ranging from 110-170 days at a soil pH of 7.5 and a temperature of 3°C-10°C (Sagik et al. in Sopper and Kerr 1979).

The ability of viruses to attach to soil particles depends upon the pH of the water/soil environment, the ionic composition, soil saturation, soil type, and to some degree, the type of virus. Virus adsorption is rapid at pH values less than 7.5 and optimal at pH 5.5-6.5. The higher the pH level, the lower the virus adsorption rate.

Viruses adsorb readily to soils with high clay or silt contents and poorly to sandy soils. Both the type and strain of virus will affect rates of adsorption (Metro Sludge Intensive Monitoring Report 1983c).

Table 3-18. Quantities Which Must be Consumed at One Time to Result in Salmonellosis and the Time Required for an Average Adult to Consume that Quantity

	During and Immediately Following Application		Three Months After Application	
	Quantity[1]	Time[2]	Quantity[1]	Time[2]
Aerosols	>1,000,000M^3	137 yrs	NA[4]	NA[4]
Sludge-soil-litter	7-70 lbs	[3]	>70 lbs	[3]
Surface water	88 to >880 gal	176 days to >4.8 yrs	>880 gal	>4.8 yrs
Groundwater	>880 gal	>4.8 yrs	>880 gal	>4.8 yrs

NOTES: [1] Quantity of air, sludge/soil or water which must be consumed at one time to result in intake of minimum infectious dose.

[2] Time required for an average adult to consume the given quantity. Adults normally consume one-half gallon of water and 20M^3 of air daily.

[3] It is not expected that anyone will consume soil from the demonstration area.

[4] Aerosols are only of concern during application.

All data are currently being reviewed and are subject to change.

SOURCE: Metro 1983a.

The levels of virus concentrations normally required to cause infection and diseases in humans vary depending on virus species and human health conditions (see Table 3-19 for an example using enterovirus infection).

Types of parasites found in sludge include Ascaris lumbricoides, Giardia lamblia, coccidia and other helminths. A detailed description of these parasites and their levels in West Point and Renton sludge is found in Appendix A.

Sludges often contain eggs and cysts, the most resistant stages of parasites. The survival of these eggs and cysts in the soil depends on such factors as soil type, moisture, temperature, pH, types and number of parasites, land topography climatic conditions, and subsequent land use (Little in Bitton et al. 1980; Metro 1982).

Ascaris eggs are generally the most resistant to various environmental conditions and have remained viable in the soil for 15 years. Trichuris eggs have also been reported to survive for several years in the soil (Little in Bitton et al. 1980).

The levels of parasite concentrations normally required to cause infection and diseases in humans vary depending upon parasite species and human health characteristics (see Table 3-20 for an example using ascaris/giardia infection).

Trace Metals -- Trace metals in sludge of greatest public health concern are lead, copper, nickel, zinc, cadmium and molybdenum (Lee and Jones in Sagik and Sorber 1978; Pilchuck Citizen's Advisory Committee Minutes October 1982). Figure 3-11 shows the possible heavy metal transmission routes from forest sludge application to humans (Metro 1983e).

West Point and Renton sludge contains arsenic, cadmium, chromium, copper, lead, mercury, nickel and zinc. Other heavy metals, barium boron, molybdenum, selenium and silver are monitored, but have not been detected in either West Point or Renton sludge (Metro 1983a). A detailed description of those metals and their levels in Metro sludge is found in Appendix A.

The detention and activity of heavy metals in soil is affected by soil pH, organic matter content, clay content, and applied sludge concentration levels. A detailed description of heavy metal movement and concentration levels at the Pilchuck demonstration sites is given in the soils section and Appendix B of the EIS. Certain heavy metals (lead, mercury, chromium and silver) are insoluble elements which are not easily transported through the soil or absorbed by plants. Other heavy metals (zinc, copper, nickel, boron, cadmium and arsenic) are known to cause phytotoxicity in plants if applied in excessive amounts.

The levels of heavy metal concentrations normally required to cause human health problems vary depending upon type of metal, type of consumption, and human health characteristics (see Table 3-21 for an example using cadmium).

Table 3-19. Quantities Which Must be Consumed at One Time to Result in Enterovirus Infection and the Time Required for an Average Adult to Consume that Quantity

	During and Immediately Following Application		Three Months After Application		One Year After Application	
	Quantity[1]	Time[2]	Quantity[1]	Time[2]	Quantity[1]	Time[2]
Aerosols	>400M^3	>20 days	NA	NA	NA	NA
Sludge-soil-litter	0.1-1 lb	[3]	1 lb	[3]	>1 lb	[3]
Surface water	400 gal	2.2 yrs	>400 gal	>2.2 yrs	>400 gal	>2.2 yrs
Groundwater	>400 gal	>2.2 yrs	>400 gal	>2.2 yrs	>400 gal	>2.2 yrs

NOTES: [1] Quantity of air, sludge/soil or water which must be consumed at one time to result in intake of minimum infectious dose.

[2] Time required for an average adult to consume the given quantity. Adults normally consume one-half gallon of water and 20M^3 of air daily.

[3] It is not expected that anyone will consume soil from the demonstration site.

All data are currently being reviewed and are subject to change.

SOURCE: Metro 1983e.

Table 3-20. Quantities Which Must be Consumed at One Time to Result in Ascaris/Giardia Infection and the Time Required for an Average Adult to Consume that Quantity

	During and Immediately Following Application		Three Months After Application	
	Quantity[1]	Time[2]	Quantity[1]	Time[2]
ASCARIS				
Aerosols	No data[4]		NA	
Sludge-soil-litter	>.25 lb/4 oz	[3]	>.25 lb	[3]
Surface water	>100 gal	>200 days	>100 gal	>200 days
Groundwater	>100 gal	>200 days	>100 gal	>200 days
GIARDIA				
Aerosols	No data[4]		No data[4]	
Sludge-soil-litter	>2.2-5.5 lbs	[3]	>2.2-5.5 lbs	[3]
Surface water	>1,000-2,500 gal	>5.5-13.7 yrs	>1,000-2,500 gal	>5.5-13.7 yrs
Groundwater	>1,000-2,500 gal	>5.5-13.7 yrs	>1,000-2,500 gal	>5.5-13.7 yrs

NOTES: [1] Quantity of air, sludge/soil or water which must be consumed at one time to result in intake of minimum infectious dose.

[2] Time required for an average adult to consume the given quantity. Adults normally consume one-half gallon of water and $20M^3$ of air daily.

[3] It is not expected that anyone will consume soil from the demonstration area.

[4] No data exist for parasites in aerosols but, based on low levels in Metro sludge, no illness would be expected.

All data are currently being reviewed and are subject to change.

SOURCE: Metro 1983e.

Table 3-21. Daily Human Consumption Necessary to Cause Health Problems from Cadmium or Lead

Substance	Cadmium		Lead	
	Quantity (1)	Multiple of Normal Consumption	Quantity (2)	Multiple of Normal Consumption
Sludge-soil-litter (3)	0.004 lbs.	(6)	0.001 lbs.	(6)
Sludge/Soil Plow Layer (4)	0.02 lbs.	(6)	0.007 lbs.	(6)
Tree Farm Soil (5)	0.04 lbs.	(6)	0.016 lbs.	(6)
Surface water	>80 gal.	> 160	>40 gal.	>80
Groundwater	>80 gal.	>160	>40 gal.	>80
Edible forest undergrowth (trailing blackberry)	0.26 lbs.		unlimited	infinite
Deer liver (sludge area)	0.07 lbs.	(7)	0.18 lbs.	(7)
(unsludged area)	0.17 lbs.	(7)	0.83 lbs.	(7)
Deer kidney (sludge area)	0.01 lbs	(7)	0.11 lbs.	(7)
(unsludged area)	0.02 lbs.	(7)	0.18 lbs.	(7)

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(1) Cd toxicity based on 200 ug daily ingestion from all sources for 50 years

(2) Pb toxicity based on 150 ug daily ingestion by children over an undetermined period. Adults can safely consume twice as much lead as children.

(3) Assumes a mixture of 1 part sludge to 2 parts soil on a dry weight basis or 1 inch of sludge mixed with 1/4 inch of soil.

(4) Assumes a mixture of 1 part sludge to 30 parts soil on a dry weight basis or 1 inch of sludge mixed with 4 inches of soil.

(5) Based on 1.6 mg/kg Cd and 21 mg/kg Pb avg. measured content in soil at Pilchuck Tree Farm.

(6) It is not expected that anyone will consume soil from the demonstration area.

(7) Cannot calculate because normal intake not known.

SOURCE: 1983e.

Organic Compounds -- The two major groups of organic compounds in sludge of public health concern are organochlorine pesticides and polyaromatic hydrocarbons. The possible transmission routes of organic compounds from forest sludge application to humans are shown in Figure 3-12.

West Point and Renton sludges contain no detectable amounts of chlordane, dieldrin, DDT, aldrin, endrin, lindane, methoxychlor, toxaphene, 2,4-D and 2,4,5-TP (silvex). However, polychlorinated biphenyls (PCBs) are found in low concentrations in both West Point and Renton sludges (Metro 1983a). A detailed description of these organic compounds and their levels in sludge is found in Appendix A.

The persistence and decomposition of organic compounds in soil is influenced by such factors as photodecomposition, chemical and microbiological decomposition, detoxification by crop plants or weeds and soil characteristics. The ability of soils to adsorb organic pesticides could also help to decompose these compounds, by concentrating the compounds near the soil surface where microbial activity occurs. In many instances, however, organic compounds are not decomposed in the soil but transferred and diluted. Such transfer and dilution processes include volatilization, movement into and out of plants by adsorption and exudation, retention by crops and weeds, runoff into streams and lakes, movement downward into the soil in percolating water and upward from lower depths by capillary flow, and adsorption and inactivation by soil constituents (EPA 1980b). A detailed description of organic compounds, their movement, and their concentration levels at demonstration sites is given in the soils section of this EIS.

Little information is available on the amount of organic compounds taken up by plants in the food chain and their potential toxicity to humans (EPA 1980b). The most important factors controlling organic compound uptake by plants are water solubility; solute concentration; size and polarity of organic compound molecules; and soil organic content, pH, clay and microbial activity. Climatic factors also play an important role (Pahren et al. 1979).

The levels of organic compound concentrations normally required to cause human health problems varies depending upon type of organic compound and human health characteristics (an example using PCBs is shown in Table 3-22).

Exposure of Workers and the Public to Sludge Contaminants -- Workers transporting, handling, and spraying sludge onto the application sites would receive the greatest exposure to the aforementioned contaminants. The greatest exposure to sludge would be during transfer from haul trucks to the basin, from the basin to the nursing vehicle or application vehicle, and during any equipment cleanup at the sludge storage facilities.

Table 3-22. Quantities Which Can be Consumed on a Continuous Basis Without Exceeding Standards or Criteria for PCBs

Point of Transmission	Quantity	Comments
Aerosols	Unknown	No data
Soil	15 g (0.6 oz)	Used 1.2 ppm PCBs in soil and .3 ppm in food as standard 7.5 g soil equivalent to eating one egg with .3 ppm PCBs (Kaldriko and Nelson 1979)
Surface water	Not quantifiable	Detection limit is above recommended EPA criteria. Based on work of Kaldriko and Nelson 1979, surface erosion and subsequent surface water contamination should be undetectable.
Edible plants	Unlimited	Sludge maximum PCBs levels are four times lower than EPA-recommended PCB concentrations for agricultural use.
Animal meat	Unknown[1]	Deer fat tissue could potentially accumulate PCBs but deer fat is not usually eaten by hunters.
Groundwater	Unknown	Detection limit is above EPA-recommended criteria. However, no detectable leaching of PCBs to groundwater is anticipated.

[1] Cattle fed a diet which has 11 percent sludge with a PCBs content higher than Metro sludge did not accumulate PCBs in body fat higher than FDA standards (Baxter et al. 1980).

Note: All data are currently being reviewed and are subject to change.

SOURCE: Metro 1983e.

The sludge to which the workers would be exposed would have gone through an anaerobic digestion process, which is considered by EPA as a "process to significantly reduce pathogens." Anaerobic digestion at Metro's West Point Treatment Plant reduces pathogens by approximately 85-90 percent. There have been no illness incidents to date affecting any of Metro's hauling contractors.

Because the sludge application vehicle would have a remote-control powered cannon-type sprayer, the vehicle operator would be protected from exposure to the sludge by the enclosed cab.

Because the application sites would be closed to public access during application and for a year thereafter, very few people would likely be exposed directly to the sludge. Access would be controlled by a locked gate and signs along the perimeter of the site, in addition to the steep cliffs surrounding much of the east, south and west portions of the sites.

Metro (1983d) proposes to continue to keep the site closed to public use for 1 year following sludge application. Data suggest that 1 year is sufficient time to achieve die-off for a majority of the microbial organisms. Insufficient data exist, however, regarding the longevity or concentrations of trace metals in soils and uptake by edible mushrooms and berries. Research on those subjects is scheduled to continue at Pack Forest and to be a part of future studies conducted by the University of Washington on the Pilchuck demonstration sites.

The potential contaminant pathways through groundwater and surface water were discussed in previous sections of this chapter and will not be repeated here. Because of the isolated nature of the site and the movement of groundwater away from private drinking wells, the likelihood of groundwater contamination representing a public health hazard is remote.

Aerosols generated during sludge spraying and from the surface of sludge applied to soil represent one potential pathway of exposure to sludge pathogens. Few studies have been conducted on the production of aerosols from the spray application of sludge. Although Harding et al. (1980) evaluated aerosol production from sludge applied by tank truck and by spray irrigation, a majority of the information on aerosol production has related to wastewater application (Sorber et al. in Sopper and Kerr 1979; EPA 1981c). Harding et al. (1980) found that sludge aerosol production using tank truck application was intermittent and difficult to detect because of the constant movement of the application vehicle. The Harding study concluded that aerosols are generated and transported from the sprayed area but that the transport is limited. No data were provided regarding the percent of aerosolization of sludge applied by truck; however, data from fixed-head sludge spray sites showed aerosolization to be low, ranging from 0.00070-0.037 percent as compared to aerosolization of spray applied wastewater which has been shown to range from 0.1-1.5 percent (EPA 1981c).

The distance that aerosols move off-site would depend on such factors as wind speed and direction, relative humidity, interference caused by vegetation, solar radiation, and air temperature. Harding et al. (1980) concluded that the transport of and exposure to aerosols can be minimized by initiating the following practices:

- Creation of a buffer zone around the application site.
- Application of sludge during daylight hours when periods of high solar radiation and low humidity would reduce concentrations of aerosols.
- Limiting spraying during periods of high wind conditions.

Metro has already established a buffer zone between the application site and the residential area to the north. The sludge operation plan to be developed by Metro would specify the allowable conditions for sludge application (Sasser pers. comm.).

The distances of aerosol drift and likely pathogenic concentrations from the demonstration site cannot be determined without specific monitoring; however, given the likely small percent of aerosolization (less than 0.05 percent) and the width of the buffer zone on the north side of the application area (500 feet), the impacts associated with aerosol drift resulting from this project are projected to be minor. The effects of forest canopy on aerosol production and drift are not well understood (Edmonds and Mayer in Bledsoe 1981).

Proposed Pathogen Monitoring Program -- A part of the Pilchuck demonstration project would include an intensive monitoring program. A major Metro objective of the program would be to "provide assurance to local residents and agencies that potential contaminants are contained on the site without jeopardy to public health or environmental quality" (Metro 1982c). The proposed program would conform with monitoring guidelines identified in DOE's BMPs (1982a).

The surface water and groundwater monitoring programs were previously described in the surface water and groundwater evaluations of the Pilchuck project. In addition to water quality monitoring, the soil and sludge mix would be monitored for bacterial die-off at two locations.

Prior to project startup, Metro would need to receive a permit for land application of sludge from the Environmental Health Division of the Snohomish Health District. Site-specific information such as the physical characteristics of the site (soils, depth to groundwater), sludge characteristics, sludge volume to be applied, and a site development map are necessary components of permit application. Following permit approval, the Snohomish Health District would conduct periodic site inspections, review all monthly, bimonthly and quarterly monitoring data and provide an annual review at the end of each annual permit period (Willey pers. comm.).

Mitigation Measures. A number of mitigation measures for surface water and groundwater impacts were previously described. One additional measure should be considered to minimize the likelihood of impacts caused by aerosol drift:

- As a general rule, sludge spraying closest to the residential area should be accomplished on days of no wind or when the prevailing wind directions is away from the residential areas.

With regard to public use of the site following sludge application, the following measure should be considered:

- Results of studies of mushrooms, edible berries, and wildlife conducted at the site should be used to determine the need to limit public activities on the site to a period longer than 1 year after sludge application.

As a consideration for ensuring that sludge is applied on the site in a uniform and consistent manner, Metro is considering the following measures:

- Development of site operations procedures.
- Development of a procedure for clearly delineating unit areas designated for sludge application (i.e., marking boundaries for each truckload of sludge).

Chapter 4

Coordination

- Public Participation
- Scoping Process
- Upcoming Coordination Efforts

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Chapter 4

COORDINATION

Introduction

EPA's procedures for implementation of NEPA require that EISs discuss the extent and results of coordination activities conducted prior to publication of EISs (40 CFR 6.203). This chapter describes the involvement of government agencies, interest groups, and the public in general in determining the scope and content of this EIS.

Public Participation

Public participation for this EIS has been coordinated, and, where possible, integrated with the full-scale public participation program undertaken by Metro in preparing its Draft Sludge Management Plan and the Pilchuck demonstration project. Key EIS public participation activities to date are summarized below.

Information Brochure

In October 1981, EPA published a brochure entitled Municipality of Metropolitan Seattle Sludge Management Program. This widely-distributed brochure provided background information on the sludge management plan being prepared by Metro, listed and discussed key issues for the EIS, described EPA's role in decision making and in preparing the EIS, and identified future public involvement opportunities. The brochure also included a Notice of Intent inviting members of the public to attend the initial project "kickoff" and scoping meetings.

Scoping Meetings

Joint scoping meetings were held by Metro and EPA in December 1981. Metro staff explained the planning approach and gave examples of sludge application projects previously undertaken by Metro. In addition to Metro's presentation, presentations were made by EPA staff and the EIS consultant regarding EPA's role in preparing the EIS and some of the important issues to be addressed in the EIS. A responsiveness summary was prepared and distributed in April 1982.

Notice of Intent

On November 6, 1981 EPA's Notice of Intent to prepare an EIS was published in the Federal Register.

Preparations to Sludge Advisory Committees

On February 15 and 16, 1983, the EIS consultant presented a report on the EIS to the Pilchuck Citizens Advisory Committee and to the Metro Sludge 201 Citizens Advisory Committee. The impacts associated with the proposed long range alternative and the proposed Pilchuck project were identified and discussed.

Comments and Suggestions Reviewed During Preparation of the Draft EIS

During the course of the Metro planning period, the Pilchuck Citizens Advisory Committee developed a list of 17 concerns associated with Metro's proposed sludge application project on the Pilchuck Tree Farm. The concerns were used as a "checklist" to ensure that the topics were addressed in the EIS.

Upcoming Coordination Efforts

This Draft EIS has been forwarded to numerous federal, state and local agencies, special interest groups, and private citizens to act as both an informational document and as an avenue to comment on the proposed sludge management project. The distribution list is shown in Appendix G. The document has been forwarded to public libraries in the study area so that other concerned residents can review the potential impact of the project.

Individuals of groups that wish to comment on the EIS may forward written comments to:

U. S. Environmental Protection Agency
Region 10
1200 Sixth Avenue
Seattle, Washington 98101
Attention: Kathryn Davidson

Comments should be sent by May 30, 1983.

Joint public hearings have been scheduled on the Draft Sludge Management Plan and Draft EIS by Metro and EPA for May 15 and May 17, 1983. Citizens and agency representatives will have a chance to learn about the plan and EIS and to present formal oral and written testimony.

All oral and written comments received on the Draft EIS will be recorded and responded to in a final EIS, which will be made available to interested individuals, groups and agencies approximately 3 months after the public hearing.

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Appendix A

PUBLIC HEALTH

Introduction

This appendix has been developed to provide the EIS reader with a brief technical overview of the nature of trace metals, bacteria, viruses, parasites, and organic toxicants monitored as a part of Metro's sludge intensive monitoring program conducted at the West Point and Renton treatment plants from May 27 through September 2, 1981 and as part of Metro's continuous monitoring program.

Not all of the constituents mentioned herein occur in Metro's sludge. For those nondetectable constituents: barium, boron, molydenum, selenium, and silver, only a brief description is presented. Information on the occurrence within Metro sludge is provided where known. Further information on effects on humans, plants, and animals, where applicable, is presented as a result of literature review.

Trace Metals

Arsenic

Arsenic is widely distributed in nature in two forms: elemental arsenic, which is a brittle metal, and as arsenides and arsenosulfides of heavy metals. Arsenic is not regarded as an essential element for human metabolism, but as a stimulant. The normal human adult's daily intake of arsenic is approximately 0.2-1 mg (Venugopal and Luckey 1978). About four-fifths of this is stored and widely distributed within the tissues.

Acute arsenic poisoning can occur in humans when large quantities are ingested. Arsenic poisoning is a general protoplasmic poison which acts upon various ferment processes, especially in the phosphates. Eventually oxidation and tissue respiration diminishes to low levels. Arsenic poisoning also has a paralytic action on smooth muscles and leads to hemorrhage.

Chronic symptoms of arsenic poisoning can occur in humans who inhale arsenic dust. The chronic symptoms include loss of weight, gastrointestinal disturbances, skin eruptions, loss of hair, and peripheral neuritis (Browning 1961).

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Nationwide, arsenic has been found in sludge at levels ranging from 1.1-230 mg/kg dry weight with a median value around 10 mg/kg (Chaney 1980). Digested dewatered sludge measured at Metro's West Point plant from May 1981 to May 1982, was found to have a mean value of 14 mg/kg of arsenic while raw, waste activated sludge from the Renton's treatment plant had a mean value of 6.4 mg/kg of arsenic (Metro 1983a). The primary source of arsenic in Metro sludge is from industries (Cochran pers. comm.). The human health hazards associated with sludge containing arsenic have not been well studied (Lindsay 1973). Pahren et al. (1989) concluded that arsenic is of little threat to humans because of the low levels encountered in most sludges, its relatively insoluble nature and its ability to strongly bond to clays.

The degree of arsenic phytotoxicity depends upon whether or not plants are growing on clay or sandy soils. In clay soils, arsenic in the chemical form of arsenate is held strongly by the clay fraction and is not readily available for plant uptake. In sandy soils, arsenic is not strongly held and phytotoxicity can occur if excessive amounts are applied to those soils (EPA 1976a). With the exception of root crops, arsenic phytotoxicity generally causes reductions in crop yields before appreciable amounts accumulate in the edible plant tissues. Arsenic can accumulate in the edible peel of root crops as the soil level of arsenic increases. Bioaccumulation in the food chain is unlikely to occur from arsenic accumulation because of the low levels generally found in sludge.

Domestic animals are similarly protected against arsenic accumulation because of the low levels found in sludge (Chaney _in_ Bitton et al. 1980).

Barium

Barium occurs in nature in a wide variety of forms: as the sulfate barite or heavy spar (BaSO4), as the carbonate, witherite (BaCO3) and in zinc and iron ores. Most of the barium in the human body is stored in muscle tissue, bones, and lung tissue (Venugopal and Luckey 1978).

Acute barium poisoning can occur in humans when large quantities of soluble barium salts are ingested (Browning 1961). Symptoms of acute barium poisoning are excessive salivation, vomiting, colic, muscular paralysis and paralysis of the central nervous system.

Chronic symptoms of barium poisoning are less severe but similar in nature to the effects of acute poisoning (Venugopal and Luckey 1978). Inhalation of finely ground barium sulphate (BaSO4) can cause a chronic respiratory infection, baritosis or benign pneumoconiosis. Baritosis causes no specific symptoms and does not lead to tuberculosis. It has been demonstrated

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Neither West Point's digested, dewatered sludge nor Renton's raw, waste activated sludge was tested for barium from May 1981 to May 1982 (Metro 1983a).

Boron

Boron is widely distributed in nature as borax, colemanite, boronatrocalcite, and boracite. The normal human adult diet contains between 10-20 mg of boron per day. Much of the boron found in the human body is ingested from fruits and vegetables (Browning 1961).

Acute boron poisoning can occur in humans when large quantities of boron hydrides and boranes are inhaled. Symptoms of acute boron poisoning include muscular cramps, shortness of breath, exhaustion, mental confusion, headaches, and nervous system problems.

Chronic symptoms of boron poisoning can occur in humans who absorb small amounts of boric acid over long periods of time. This can lead to mild gastrointestinal irritation, nausea, vomiting, and rash (Browning 1961).

Boron has been found in sludge throughout the United States at levels ranging from 4-1,000 mg/kg dry weight with a median value around 33 mg/kg (Chaney 1980). Neither West Point's digested, dewatered sludge nor Renton's raw, waste activated sludge was tested for boron from May 1981 to May 1982 (Metro 1983a).

When boron is applied to croplands in excessive amounts phytoxicity in plants occurs. Because boron is so phytotoxic, severe yield reduction occurs in most plants before boron is appreciably increased in edible plant tissue. The quantity and concentration of boron entering the food chain are limited by this natural process (Chaney *in* Bitton et al. 1980). Also, the level of boron accumulation in the soil is relatively low because of the low amounts of boron in sludge (Chaney 1980).

Cadmium

Cadmium is a soft, white, easily fusible metal that occurs in nature chiefly as a sulfide salt. It is frequently associated with zinc and lead ores. This metal causes the most concern to human health when sludge is applied to land.

The major sources of cadmium intake in humans are through ingesting food and drinking water that contain various concentration levels, inhaling ambient air, and smoking cigarettes. Data have shown that 0.1-0.2 mg of cadmium are inhaled for each cigarette smoked. Thus, smoking 20 cigarettes per day would result in inhaling about 3 mg of cadmium. Although the majority of total cadmium intake is through the gastrointestinal route, only 4-5 percent is absorbed by the body. Forty-six percent of the body's cadmium is absorbed by inhalation (Pahren et al. 1979). Once absorbed into the body cadmium is stored largely in the kidneys and liver and is excreted at an extremely slow rate (EPA 1976b). Cadmium levels tend to increase in the kidney from birth to approximately age 50 and then to decrease thereafter. The median concentration of cadmium in kidneys is 32 mg/g wet weight. Smokers have been shown to have a cadmium level 50 percent higher than nonsmokers. Urine is considered to be the major means for cadmium excretion (Pahren et al. 1979).

The human kidney is the primary target organ for chronic health effects from cadmium. Renal tubular dysfunction will begin to occur in an individual when the cadmium concentration in the renal cortex reaches approximately 200-300 mg/g wet weight (Naylor and Loehr 1981). Renal damage from cadmium results in an abundance of low molecular weight serum proteins, especially B2-microglobulin in urine. Continued exposure beyond the threshold for protein uria results in proportionally greater B2-microglobulin excretion. Whether the earliest effects on the kidney are reversible when the cadmium level decreases is not known. Also still unknown is the clinical significance of minimal renal tubular damage (Pahren et al. 1979).

Itai-itai is another disease which results from high concentrations of cadmium in drinking water and diet. Symptoms of this disease are the fracturing of bones and skeletal deformations due to softening of bone tissue. These symptoms of skeletal deformation are caused by impaired calcium metabolism, calcium deficiency and impaired regulation of the calcium-phosphorus balances in the body. Itai-itai disease is the most severe manifestation of cadmium poisoning (Naylor and Loehr 1981).

The U. S. Food and Drug Administration (FDA) has estimated the average dietary intake of cadmium is 39 mg/day. This figure represents the mean of the median levels of cadmium found in foods during the years 1968 to 1974 (Naylor and Loehr 1981). The level of cadmium in foods varies.

In 1972, a joint Food and Agricultural Organization (FAO)-World Health Organization (WHO) Expert Committee on Food Additives established a provisional tolerable dietary daily intake of 57-71 mg/day of cadmium. This figures represents about 1 mg/day per kilogram of body weight. Since 1972 the EPA has established a maximum acceptable dietary intake of cadmium of 70 mg/day.

Various metabolic models have been used to project cadmium exposure levels necessary to produce critical concentration levels in the kidney. Using a model developed by Kjellstrom and Nordberg, the EPA found that the renal cortex concentrations in nonsmokers would reach 200 mg/g wet weight in 50 years with an average daily dietary intake of 440 mg of cadmium (Naylor and Loehr 1981). Smokers would reach the critical level with proportionately less intake by ingestion (Pahren et al. 1979). Sampling of digested, dewatered sludge from the West Point treatment plant has shown a mean value of 46 mg/kg cadmium while Renton's raw, waste activated sludge had a mean value of 19.4 mg/kg (Metro 1983a). Cadmium in sludge comes from street and highway runoff, industrial sources, and from the water supply system (Hilderbrand pers. comm.).

The EPA has established limits on the amount of cadmium that may be applied to food chain crops for human consumption or for crops produced for animal feed. The most restrictive annual application rates are for leafy green vegetables, root crops, and tobacco. No more than 0.5 kg/ha (0.45 lbs/acre) may be applied annually for production of those crops. For other food chain crops (e.g., corn, wheat), up to 2.0 kg/ha (1.8 lbs/acre) of cadmium can be applied annually. In all cases, the soil/sludge pH must be adjusted to 6.5 or greater at the time of sludge application (EPA, 40 CFR 257, 1979).

When sludge is applied to gardens and agricultural lands, certain crops such as grains, forage grasses, and vegetables uptake cadmium. The amount of cadmium uptaken by these crops is a function of four processes which include availability of the element in the soil, movement of the element to the root, absorption of the element by the root system, and translocation of the element into the plant. The most important factor limiting element uptake is the soil solution concentration of micronutrients. Studies have shown that the amount of cadmium applied annually influences the cadmium concentrations in plants more than does the total cumulative amounts of cadmium applied. Cadmium that has been previously applied is less available to plants than is recently applied cadmium. However, when annual cadmium applications cease, the cadmium stored in the soil becomes available to crops (Pahren et al. 1979). In contrast to these ideas, Chaney (1973) suggests that it is not the cadmium concentrations in the soil that determine cadmium uptake by plants. As long as the ratio of zinc to cadmium is 100 or greater, food plants will not uptake and accumulate hazardous concentration levels of cadmium (EPA 1976b).

Fish, such as salmonids and certain invertebrates, have been found to be sensitive to low levels of cadmium. If exposed to high enough concentrations edible marine organisms also concentrate cadmium and can become hazardous to the ultimate consumer (EPA 1976b).

Chromium

Chromium occurs most predominately in nature as chrome iron ore (Venugopal and Luckey 1978). There are two biologically significant valence states in which chromium occurs as trivalent and hexavalent. The normal human adult body contains about 6 mg of chromium. No particular tissue retains high concentration levels. Chromium can accumulate in the lungs with age, but the levels are usually harmless.

Chromium is an essential component of the glucose tolerance factor. Because of its low molecular weight, chromium can act as a cofactor for insulin activity and help to alleviate some of the symptoms of diabetes. Chromium is also important with carbohydrate and lipid metabolism, and membrane transportation of cell metabolites (Venugopal and Luckey 1978).

Chromium toxicity is attributed to the hexavalent state (Hammond and Beliles 1980). The principal toxic effects of chromium in humans results from exposure to chromium compounds in industries and ingestion of potassium dichromate. Workers who are exposed to chromium compounds develop skin problems, lesions on the nasal mucosa, and inflammation of the larynx (Browning 1961). Ingestion of potassium dichromate causes gastrointestinal ulceration and affects the central nervous system (Venugopal and Luckey 1978).

Nationwide, chromium has been found in sludge at levels ranging from 10-99,000 mg/kg dry weight with a median value around 500 mg/kg (Chaney 1980). From May 1981 to May 1982, West Point's digested, dewatered sludge had a mean value of 390 mg/kg of chromium and Renton's raw, waste activated sludge had a mean value of 287 mg/kg of chromium (Metro 1983a). The chromium found in sludge comes from a variety of industrial sources including electroplaters (Cochran pers. comm.). The human health hazards associated with sludge containing chromium have not been well studied. It is known, however, that all hexavalent chromium is reduced to the less toxic trivalent state either during sludge digestion (Pahren et al 1979) or after sludge is applied to the soil (Chaney 1973).

Trivalent chromium in the soil is an insoluble element, (i.e., an element that is tightly bonded to soil particles). Because of chromium's insoluble nature, plants are unable to accumulate large quantities, even in the presence of high soil levels (Pahren et al. 1979). Thus, the likelihood of chromium accumulating in the food chain is low.

Trivalent chromium is an essential component of animal diets. It aids in the metabolism of glucose and lipids (Hammond and Beliles 1980).

Copper

Copper is widely distributed in nature as a native metal and in sulfide ores, malachite, cuprite, and chalcopyrite. The normal human adult body contains about 100 mg of copper. About one-third of this is stored in muscle tissues. Other storage areas include the brain and the liver.

Copper is an essential component of iron utilization, connective tissue formation, pigmentation and enzymes used in energy production. The human body has an effective hemostatic mechanism which regulates the absorption of copper. Copper deficiencies in humans result in anemia, abnormal bones, poor growth, defective connective tissue, cardiovascular failure, and death (Venugopal and Luckey 1978).

Copper poisoning often occurs in humans following over-exposure to agricultural insecticides or other toxic copper salts and inhalation of metal dust (Venugopal and Luckey 1978).

The level of copper in sludge ranges from 84-17,000 mg/kg dry weight with a median value of 800 mg/kg (Chaney 1980). From May 1981 to May 1982, West Point's digested, dewatered sludge had a mean value of 1,160 mg/kg of copper and Renton's raw, waste activated sludge had a mean value of 997 mg/kg of copper (Metro 1983a). In the Seattle area, the main source of copper in sludge is primarily from the water supply system (Cochran pers. comm.). The human health hazards associated with sludge containing copper are slight because of the human body's hemostatic mechanism (Hammond and Beliles 1980).

Copper can cause phytotoxicity in plants if applied in excess amounts to croplands. Because copper is so phytotoxic, severe field reduction occurs in most plants before copper is appreciably increased in edible plant tissue. Generally, plants show phytotoxicity at about 25-40 mg/kg dry weight. The food chain is basically protected from copper accumulation because of these two factors (Chaney in Bitton et al. 1980).

Copper toxicity to domestic animals and ruminants from sludge-fertilized crops appears extremely unlikely. Studies have shown that after direct consumption of sludge or sludge-contaminated forages or sludge from the soil surface, the interaction of other dietary constituents with copper is so pronounced that copper concentrations in the liver were depleted rather than increased to toxic levels (Chaney in Bitton et al. 1980). The likely consequence of applying sludge containing large quantities of copper is a reduction in molybdenum available for animal dietary intake. This is especially possible in areas already low in molybdenum (Chaney 1980). According to EPA (1977) it has been demonstrated that the total cumulative loading of 125-500 kg/ha (depending on the cation exchange capacity) of copper to agricultural land has not led to observed problems.

Lead

Lead is a metal which is found in galena, an abundant lead ore. The normal human adult body contains between 100-400 mg of lead, depending upon body weight (Browning 1961). Almost 96 percent of the body's total lead content is stored in the bones, with the remaining 4 percent being stored in soft tissues such as liver, kidneys, and brain. The concentration of lead in humans increases with age (Venugopal and Luckey 1978).

The toxicity of lead is related more to the levels of diffusible lead and to the lead content of soft tissues than to the total content of lead in the body. Lead poisoning is cumulative and acute toxic symptoms include lassitude, vomiting, loss of appetite, uncoordinated body movements, convulsions, and eventually death. Chronic lead poisoning symptoms include loss of appetite, vomiting, renal malfunction, hyperactivity, liver cirrhosis, brain damage, and general intellectual and psychological impairment. Lead poisoning can result from a variety of sources: ingestion of lead from lead-glazed clay cooking utensils, paints, newsprint, waterfowl has been killed by lead-shot, inhalation of lead pigment in paints, lead fumes from gasoline, and lead smelting operations (Venugopal and Luckey 1978).

Nationwide the level of lead in sludge ranges from 13-26,000 mg/kg dry weight with a median value around 500 mg/kg (Chaney 1980). From May 1981 to May 1982, West Point's digested, dewatered sludge had a mean value of 720 mg/kg of lead and Renton's raw, waste activated sludge had a mean value of 280 mg/kg of lead (Metro 1983a). The lead found in Metro sludge comes primarily from industries, the water supply system, and urban runoff. Urban runoff, which accounts for 10 percent of the lead in sludge, comes mainly from automobile exhaust (Cochran pers. comm.). The human health hazards associated with sludge containing lead vary with the concentration levels. Sludge having over 1,000 mg/kg of lead may pose a threat to humans, especially children if the lead-contaminated soil is ingested directly (Chaney 1980).

Lead is generally not toxic to plants. The amount of lead taken up from the soil depends upon soil pH, cation-exchange capacity and availability of phosphorus. Generally, as these factors increase, the amount of lead taken up from the soil decreases (EPA 1976a). Lead is considered to be an insoluble element in the soil (Chaney in Bitton et al. 1980). Insoluble elements are generally held strongly by the clay fraction and are not readily available for plant uptake and translocation. In general, any lead taken up by plants accumulates in the roots and not the fruits and seeds (EPA 1976a). The food chain is basically protected from lead accumulation by the insoluble nature of lead and the adsorption to clay soil particles.

Lead toxicity in animals occurs when the dietary intake approaches 30 mg/kg. Animals foraging on crops grown on sludge fertilized croplands are generally protected from absorbing excess lead. However, when animals directly consume high lead-contaminated soil, toxicity may result (Chaney _in_ Bitton et al. 1980). According to the EPA (1977), it has been demonstrated that total cumulative loading of 500 (cation exchange capacity of 0-5 meq/100 g) to 2,000 (cation exchange capacity of greater than 15 meq/100 g). Kg/ha of lead to agricultural land has not led to observed problems.

Mercury

Mercury occurs chiefly in the form of cinnabar ore. The normal human adult body contains about 13 mg of mercury. Almost 70 percent of the body's total mercury content is stored in fat and muscle tissue. Trace amounts are also stored in hair and nails (Venugopal and Luckey 1978).

Mercury is toxic in all forms. Acute symptoms of mercury poisoning vary, depending upon what form of mercury was either ingested or inhaled. For example, inhalation of elemental mercury vapor causes damage to the nervous system and possibly death. Inorganic mercury intoxication causes nausea, abdominal pain, stomatitis, gingivitis, and other more serious conditions (Venugopal and Luckey 1978).

Mercury toxicity is a world-wide problem. Mercury poisoning can result from exposure to agricultural insecticides and fungicides containing mercury, eating fungicide-treated seed grain or meat from animals fed such grain, seafood from mercury-contaminated waters, and from inhalation of mercury vapors in scientific and medical laboratories (Venugopal and Luckey 1978).

Nationwide the level of mercury in sludge ranges from 0.6-56 mg/kg dry weight with a median value around 6 mg/kg (Chaney 1980). From May 1981 to May 1982, digested, dewatered sludge from West Point had a mean value of 6.2 mg/kg of mercury while raw, waste activated sludge from Renton's had a mean value of 3.1 mg/kg of mercury (Metro 1983a). The source of mercury in Metro sludge is unknown (Cochran pers. comm.).

Mercury is generally not phytotoxic to plants because mercury in the soil is an insoluble element (Chaney _in_ Bitton et al. 1980). Even with the increased amounts of mercury in the soil from sludge applications, plants have not increased the amount of mercury uptaken to a point of toxicity (Chaney 1980).

Molybdenum

Molybdenum occurs naturally as molybdenite sulfide and as lead and iron molybdates. The normal human adult body contains approximately 9.3 mg of molybdenum. Molybdenum is stored in the body in the skeleton and the liver.

Molybdenum has low toxicity for humans and is generally not considered a serious hazard (Venugopal and Luckey 1978).

Nationwide the level of molybdenum in sludge ranges from 1.2-40 mg/kg dry weight with a median value around 10 mg/kg (Chaney 1980). Neither West Point's digested, dewatered sludge nor Renton's raw, waste activated sludge was tested for molybdenum from May 1981 to May 1982 (Metro 1983a).

The amounts of molybdenum uptaken by plants depends primarily on the soil pH. In highly acid soils, little molybdenum is available for plant uptake (Lindsay 1973). In calcareous soils, plant uptake is high because molybdenum sorption is weak (Chaney *in* Bitton et al. 1980). Plants can tolerate high levels of molybdenum without phytotoxic effects (Chaney 1980). Once molybdenum has been taken up by plants, it can easily be transported to the edible portions of plants.

Ruminant animals are susceptible to molybdenum toxicity because molybdenum can react to bind upon dietary copper in the liver (Chaney *in* Bitton et al. 1980). Only substantially molybdenum-polluted sludges cause toxicity in ruminant animals because generally sludges also contain copper which interacts with the molybdenum (Chaney *in* Bitton et al. 1980).

Nickel

Nickel is widely distributed in nature as deposits of sulphide ore which contain pentlandite, chalcopyrite, pyrrhotite and in combination with arsenic in kupfernickel, nickleglance, and nickelblende (Browning 1961). The normal human adult body contains about 10 mg of nickel, with approximately 18 percent deposited within the skin. The remainder is distributed throughout the body (Venugopal and Luckey 1978).

Humans are exposed to nickel compounds from the soil, water, atmosphere, and plants. The toxicity of nickel is considerably less serious than is its possible carcinogenicity. Acute toxicity will cause severe gastroenteritis and chronic toxicity results in degenerative changes in the heart muscle, brain, lung, liver, and kidney (Venugopal and Luckey 1978).

In the United States the level of nickel in sludge ranges from 2-5,320 mg/kg dry weight with a median value of approximately 500 mg/kg (Chaney 1980). From May 1981 to May 1982 digested, dewatered sludge from the West Point treatment plant had a mean value of 155 mg/kg of nickel while raw, waste activated sludge from Renton's had a mean value of 91 mg/kg of nickel (Metro 1983a). Nickel found in Metro sludge comes primarily from electroplating industries (Cochran pers. comm.). The human health hazards associated with sludge containing nickel are not considered to be of significant concern because nickel is readily excreted from the body and of low toxicity to humans (Lucas et al. 1978).

Nickel can cause phytotoxicity in plants if applied in excess to croplands. Nickel phytotoxicity appears in most plants when nickel levels reach about 50-100 mg/kg dry weight in the leaves. This is true for grasses, legumes, and leafy vegetables. Low soil pH enhances phytotoxicity in plants (Lucas et al. 1978).

Nickel toxicity in ruminants and monogastric animals is generally not a problem. When nickel was added to cattle diets, no toxicity was observed at 250 mg/kg. Grains and garden crops also do not accumulate high levels of nickel which could be toxic to monogastric animals (Chaney 1980). According to EPA (1977), it has been demonstrated that total cumulative loading of 50-100 kg/ha (depending on soil cation exchange capacity) of nickel to agricultural land has not led to observed problems.

Selenium

Selenium occurs naturally as metallic selenides in very small quantities. The average human adult body contains about 13 mg of selenium, with approximately 40 percent stored in muscle tissue.

Selenium intoxication can occur in humans from consuming cereals, grains, and vegetables grown on soils containing up to 5 mg/kg selenium and meat of animals reared in seleniferous areas. Selenium toxicity or selenosis, can be caused by both organic and inorganic forms. Symptoms of acute selenium poisoning include nervousness, fever, vomiting, and decreasing blood pressure. Chronic toxicity produces depression, gastrointestinal disturbances, kidney, liver and spleen damage, hemolytic anemia, and loss of nails and hair (Venugopal and Luckey 1978).

Nationwide, selenium has been found in sludge at levels ranging from 1.7-17 mg/kg with a median value of 5 mg/kg dry weight (Chaney in Bitton et al. 1980). Neither West Point's digested, dewatered sludge nor Renton's raw, waste activated sludge was tested for selenium from May 1981 to May 1982 (Metro 1983a).

No serious human health hazards are associated with sludge containing selenium except in areas where crops are grown on soils that have naturally high concentrations of selenium (Lucas et al. 1978).

Selenium is readily absorbed from the soil by plants. Once absorbed it is translocated to edible portions of plant tissue. Plants generally can accumulate toxic levels of selenium without showing signs of phytotoxicity. In areas where naturally high concentration levels of selenium occur in soils, or in areas of high soil pH, the level of plant uptake is great. In such areas, the food chain is generally not protected; however, sludge concentrations of selenium are quite low and consequently the amount absorbed by plants in the food chain is small.

Ingestion of sludge containing 5 mg/kg of selenium has not adversely affected grazing ruminants (Chaney *in* Bitton et al. 1980).

Silver

Silver occurs in nature as free metal in ores such as argentite and horn silver. The normal human adult body contains about 1 mg of silver. The total amount of silver in the body varies with the length of time an individual is exposed to silver compounds (Venugopal and Luckey 1978).

Silver toxicity in humans can occur after free silver is either inhaled or ingested. Acute toxicity symptoms following the ingestion of silver nitrate include severe gastroenteritis, diarrhea, decrease in blood pressure and decrease in respiration rate, and eventually death. The central nervous system is also affected by acute toxicity. Chronic toxicity symptoms from low levels of silver salts are fatty degeneration of liver and kidneys, changes in blood cells and argyria (Venugopal and Luckey 1978).

Neither West Point's digested, dewatered sludge nor Renton's raw, waste activated sludge was tested for silver from May 1981 to May 1982 (Metro 1983a). Any silver found in Metro sludge is likely to come from industries such as photo finishing (Cochran pers. comm.).

Silver is generally not phytotoxic to plants because it is an insoluble element in the soil. Insoluble elements are not uptaken and translocated by plants in large quantities, thus the chances of silver accumulating in the food chain are quite low (Chaney *in* Bitton et al. 1980).

Zinc

Zinc occurs in nature in a wide variety of forms: as the sulfide blend or sphalerite as silicate, calamine, willemite or zinc spar, and as the oxide zincite. The average human adult body contains about 2,300 mg of zinc, with 65 percent in the muscle, 20 percent in the bone, 6 percent in plasma, 2.8 percent in the erythrocytes, and 3 percent in the liver.

Zinc and its salts are relatively nontoxic to humans because of an efficient zinc hemostatic mechanism in the body. If taken in large doses, however, zinc soluble salts can cause vomiting and diarrhea. Industrial inhalation of zinc oxide fumes can cause metal fume fever, and zinc chloride fumes in heavy concentrations have been found to be highly toxic and even lethal in some cases (Venugopal and Luckey 1978).

Nationwide, zinc has been found in sludge at levels ranging from 101-149,000 mg/kg dry weight with a median value around 1,700 mg/kg (Chaney 1980). From May 1981 to May 1982 West Point's digested, dewatered sludge had a mean value of 1,780 mg/kg while Renton's raw, waste activated sludge had a mean value of 644 mg/kg (Metro 1983a). The zinc found in sludge comes primarily from the water supply system (Cochran pers. comm.). The human health hazards associated with sludge containing zinc are slight because of the human body's hemostatic mechanism. Because many individuals consume low amounts of zinc, additional amounts of zinc taken into the body from eating plants grown on sludge amended soils might be beneficial (Chaney in Bitton et al. 1980).

Zinc can cause phytotoxicity in plants if applied to croplands in excess. In general, most plants show phytotoxicity at about 500 mg/kg dry weight; leafy vegetables such as lettuce and chard do not show phytotoxicty in acid soils until foliar zinc levels are about 1,500 mg/kg dry weight. Crops grown on sludge amended soils are seldom as high as 500 mg/kg for zinc. According to EPA (1977), it has been demonstrated that total cumulative loading of 250-1,000 kg/ha (depending on soil cation exchange capacity) of zinc to agricultural land has not led to observed problems.

Zinc toxicity to domestic animals and ruminants from sludge-fertilized crops appears to result from zinc-induced copper deficiency. Toxicity in animals occurs at 300-1,000 mg/kg in diet (Chaney in Bitton et al. 1980).

Bacteria

Salmonellae

Salmonellae bacteria are gram-negative, facultative, anaerobic rods ranging in size from 0.5-3 µm. Members of the salmonellae genus are responsible for a wide variety of human and animal diseases and are often associated with food and water contamination. The most common form of salmonellae infection in humans produces gastroenteritis. Gastroenteritis symptoms include nausea, vomiting, abdominal pain, and mild to severe diarrhea. The most severe disease manifestation of salmonella is typhoid fever, caused by S. Typhi (Slack and Snyder 1978).

Salmonellae bacteria are the most frequently occurring species of enteric pathogens in sewage (Akin et al. in Sagik and Sorber eds. 1978). From May 1981 to May 1982 digested, dewatered sludge from Metro's West Point treatment plant had a mean value of 95 organisms per 100 grams (wet weight) of salmonellae while Renton's raw, waste activated sludge had a mean value of 60 organisms per 100 grams (wet weight) of salmonellae (Metro 1983a).

Salmonellae bacteria in sludge applied to land after sewage treatment persists anywhere from a few days to 7 weeks, depending upon initial concentration levels and environmental conditions. Human health problems associated with salmonellae in sludge involve potential surface and groundwater contamination and possible cross-infection between animal and man (Metro 1983c).

Shigallae

Shigellae bacteria are gram-negative, facultative, anaerobic, nonspore forming rods. Shigellae do not ferment lactose or produce hydrogen sulfide (Slack and Snyder 1978). Shigellae infection in humans can occur from digesting as few as 10-100 *S. dysenteriae* cells. The enteric diseases caused by shigellae bacteria are collectively called dysentery or shigellosis and are characterized by fever, diarrhea, and cramping.

Shigellae bacteria are found in sewage at levels lower than salmonellae. From May 1981 to May 1982 West Point's digested, dewatered sludge had a mean value of less than 0.3 MPN/100 g while Renton's raw, waste activated sludge had a mean value of less than 0.3 MPN/100 g (Metro 1983a). Neither the human health hazards associated with sludge containing shigellae bacteria nor the persistence of shigellae in sludge have been well studied.

Yersinia enterocoliticia

Yersinia enterocoliticia bacteria are gram-negative, nonspore forming facultative anaerobic rods ranging in size from 0.5-2 µm. The bacteria are motile at 22-25°C and nonmotile at 35-378°C. *Yersinia enterocoliticia* bacteria are found in domestic and wild animals and are transmitted to humans through contaminated food and water. The most common form of infection in humans is gastroenteritis. The bacteria can also cause acute mesenteric lymphadenitis, septicemia, and acute terminal ileitis (Slack and Snyder 1978).

From May 1981 to May 1982, West Point's digested, dewatered sludge has a mean value of 0.15×10^4 MPN/100 g of *Yersinia enterocoliticia* and Renton's raw, waste activated sludge has a mean value of 0.36×10^3 MPN/100 g of *Yersinia enterocoliticia*

(Metro 1983a). *Yersinia enterocoliticia* bacteria was suggested by Turnberg to be more resistant to disinfection by chlorination than other enteric bacteria in sewage (Turnberg 1980). Neither the length of time *Yersinia enterocoliticia* bacteria persists in sludge nor the human health hazards associated with the bacteria in sludge have been well studied.

Mycobacteria

The genus mycobacteria are generally gram-positive rods ranging in size from 2-4 μm. Mycobacteria are widely distributed throughout the environment and in humans and animals (Slack and Snyder 1978). There are approximately 12 species of mycobacteria that cause disease in humans. The best known mycobacteria, *M. tuberculosis* causes tuberculosis. *M. bovis*, the tuberculosis agent in cattle, can be transmitted to humans through close contact with infected animals. Other mycobacteria can cause skin lesions and ulcers and cervical lymphadenitis (Metro 1983c).

Mycobacteria levels were monitored at the West Point and Renton's Treatment Plants from June 1981 to August 1981 (Metro unpublished data). The mean mycobacteria level in West Point's digested, dewatered sludge was 2.0×10^5 colony-forming units (CFU) per 100 grams (cfu/100 g). At Renton the mean level was 3.0×10^5 cfu/100 g. The persistence of mycobacteria in sludge varies from a few weeks to 1 year. Generally, mycobacteria are considered to be environmentally hardy and refractory to chlorination and liming (Metro 1983c; Sagik et al. *in* Bitton et al. 1980). Human health hazards associated with land application of sludge containing mycobacteria have not been well studied.

Studies of mycobacteria survival in composted sludge have shown nearly complete die-off within 14 days under temperatures of 65°C or higher. Mycobacteria survival was found to be considerably longer when low ambient temperatures (lower than 0°C) affected compost temperatures, particularly on the outer portions of windrow compost piles (Burge et al. 1978).

Fecal Coliforms

Fecal coliforms are a subgroup of total coliforms. The fecal coliforms are thermotolerant and can ferment lactose with gas production at 44.5°C. Generally, fecal coliforms are of fecal origin. *Escherichria coli* is one of the most common species of fecal coliforms found in sewage. *Escherichria coli* in humans can cause diseases in infants and adults that may range from mild diarrhea to cholera-like illness (Sagik et al. *in* Bitton et al. 1980).

From May 1981 to May 1982 fecal coliforms in West Point's digested, dewatered sludge had a mean value of 0.20 MPN/100 g wt and in Renton's raw, waste activated sludge had a mean value of 0.24 MPN/100 g wt (Metro 1983a).

The viability of *E. coli* in sludge applied to land depends upon many environmental factors. *E. coli* have been found in high concentration levels 2 months after sludge application to soils. Concentrations of *E. coli* tend to be higher in the winter season than in the summer season (Metro 1983c). Fecal coliforms from sludge-amended land have been found in groundwater sampling wells at 100 cm deep at rates of approximately 200 cells per 100 ml MPN and less. Surface water runoff from sludge-amended land has also contained high levels (5.5×10^4 cells/ml) of fecal coliforms. Forty-two days after application, the surface water runoff still contained 60 cells/ml of fecal coliforms (Metro 1983c).

Studies of fecal coliform survival in forced aeration static pile composted sludge have shown that after an initial increase in numbers, coliform bacteria were reduced to undetectable levels by the tenth day of composting (Burge et al. 1978; EPA 1978a).

Total Coliforms

Total coliforms are a group of gram-negative, nonperforming bacilli that ferment lactose with gas formation within 48 hours at 85°C. Bacteria in this group are widely distributed throughout the environment and in humans and animals. Total coliform counts are used as a standard for determining the safety of drinking water and surface water for human use.

From May 1981 to May 1982 West Point's digested, dewatered sludge had a mean value of 0.23×10^9 MPN/100 g of total coliforms and Renton's raw, waste activated sludge had a mean value of 0.30×10^9 MPN/100 g of total coliforms (Metro 1983a). Neither the persistence nor human health hazards associated with total coliforms in sludge applied to land have been well studied.

Reductions in numbers of total coliforms in composted sludge have been shown to parallel reductions in fecal coliforms and fecal streptococci numbers (Cooper and Golueke 1979).

Fecal Streptococci

Streptococci are a group of spherical, nonmotile (with exceptions), nonsporing bacteria which average 1 µm in diameter (Burnett and Schuster 1973). The bacteria are gram-positive and cocci occur in pairs and sometimes chains. Streptococci are found in intestinal tracts of humans and warm-blooded animals (Slack and Snyder 1978). Fecal streptococci are not generally associated with any one disease. They are, however, used as an indicator of fecal pollution (Munger pers. comm.).

From May 1981 to May 1982 fecal streptococci in West Point's digested, dewatered sludge had a mean value of 0.33 x 10^8 MPN/100 g wt and in Renton's raw, waste activated sludge had a mean value of 0.76 x 10^7 MPN/100 g wt (Metro 1983a). Fecal streptococci in an anaerobic digested sludge applied to land has survived in the soil for as long as 7 months (Sagik et al. *in* Bitton et al. 1980). The incidence of public health hazards associated with land application of sludge containing fecal streptococci needs further investigation, although considerable study has been made of the survival of fecal streptococci in composted sludge (EPA 1978a; Cooper and Golueke 1979).

Parasites

Ascaris lumbricoides

Ascaris lumbricoides, commonly referred to as roundworms, are one of the largest intestinal nematodes found in humans. The adult roundworm lives in the small intestine and the intermediate host for the eggs is the soil. The length of time that the eggs remain in the soil varies, depending upon the worm species and environmental condition, but it is usually a minimum of 2-4 weeks. During this time, the eggs undergo a period of development. These eggs are very resistant to a wide range of chemical and physical conditions and often remain infective in the soil for many years (Little *in* Bitton et al. 1980). When ingested by humans, either through contaminated food or water, the roundworms can cause lesions on the lungs, hemorrhage, fibrosis, and secondary bacterial infections. Acute symptoms include intestinal obstruction and nutritional deficiencies (Brooks 1963).

From May 1981 to May 1982, West Point's digested, dewatered sludge contained three positive identifications of *Ascaris lumbricoides* out of 16 samples. Renton's raw, waste activated sludge did not have any positive identifications of *Ascaris lumbricoides* out of 10 samples (Metro 1983a). There has been a considerable amount of research done on *Ascaris lumbricoides* in sewage and sludge applied to land. In general, anaerobic digestion appears to be ineffective in destroying parasites, and the dewatering process tends only to concentrate the parasite eggs (Metro 1983c). Dewatered sludge in drying beds has characteristics similar to those of soil, and in some circumstances may provide an ideal medium for *Ascaris lumbricoides* eggs to develop to the infective stage (Little *in* Bitton et al. 1980).

Giardia lamblia

Giardia lamblia is a small flagellate protozoan parasite found in the digestive tract of humans. The parasite may live harmlessly in the digestive system or be associated with diseases of the gastrointestinal tract and gall bladder. Infection with *Giardia lamblia* is called giardiasis. Symptoms include flatulence, upper abdominal pain, nervousness, weight loss, constipation, and diarrhea (Brooks 1963). *Giardia lamblia* is readily transmitted to humans by contaminated food and drink and hand to mouth contact (Beck and Davies 1981). Giardia infections are often associated with drinking water from contaminated mountain streams.

From May 1981 to May 1982, West Point's digested, dewatered sludge contained one positive identification of giardia in 16 samples and Renton's raw, waste activated sludge contained one positive identification in 10 samples (Metro 1983c). Conflicting information exists on the public health hazards of giardia in sewage. Healy and Visvesuara (1977) reported that very little was known about the role of sewage sludge in the acquisition of giardiasis. In 1978, Fox and Fitzgerald observed that giardia does not survive anaerobic digestion and consequently appears not to pose health problems in land application of digested sludge (Metro 1983c). It should be noted that giardia cysts can survive normal chlorination of city water (Beck and Davies 1981). Whether giardia can also survive chlorination in sewage treatment needs further investigation.

Enteric Viruses

Enteric viruses is a collective term that encompasses polio, coxsackie B, echo, coxsackie A, adeno, and reo viruses. All of these viruses are enteroviruses. These viruses produce a variety of symptoms in humans including gastroenteritis, paralytic polio, respiratory disease, meningitis, encephalitis, congenital heart abnormalities, skin rash, conjunctivitis, and infectious hepatitis.

Enterovirus concentrations in sewage influent can vary depending upon geographic location, climate, and nature of sewage. Residential sewage has a higher virus content than industrial sewage or combined storm and sanitary sewage. Certain enteroviruses can survive anaerobic digestion and are transmitted to soils and water during land applications of sludge (Metro 1983c).

Studies of virus survival in forced aeration static pile composting have shown destruction of indicator viruses within 13 days except at the outermost edge of the composted material (Burge et al. 1978).

West Point's digested, dewatered sludge contains eight plaque-forming units per 100 gram weight (pfu/100 g wet) of total viruses and Renton's raw, waste activated sludge contains 30 pfu/100 g wet of total viruses (Metro 1983a).

Organic Toxicants

Aldrin/Dieldrin

Aldrin and dieldrin are manmade cyclodiene insecticides. These insecticides have been used in the past to control pests on 46 agricultural crops, for treatment of soil around fruits, nuts, grains, and vegetables and for moth proofing of woolen textiles and carpets. Both of these insecticides are acutely toxic to most forms of life including anthropods, mollusks, invertebrates, amphibians, reptiles, fish, birds, and mammals. Dieldrin, which is produced when aldrin is metabolically converted, is extremely persistent in the environment (Sittig ed. 1980). The approximate half-life of aldrin in the soil is 1-4 years and dieldrin is 1-7 years (Dacre in Bitton et al. 1980). Dieldrin, because of its fat solubility, can easily accumulate in the food chain.

Aldrin and dieldrin have persisted in the environment and, in humans, cause irritability, tremor, and tonic-clonic convulsions; the central nervous system is the principal site of action. The insecticides also have a potential carcinogenic effect (U. S. HEW 1978a and b).

Both of these insecticides have been banned by EPA since 1974. Certain restricted uses of aldrin and dieldrin are, however, currently permitted (Frandsen pers. comm.).

Sludge monitored at the West Point and Renton's treatment plants from May 1981 to May 1982 did not contain any detectable amounts of aldrin or dieldrin (Metro 1983a). Specific sources of aldrin and dieldrin in sewage are not known; however, traces of the insecticides in sewage may be from either incidental uses or from residues in the environment (Cochran pers. comm.).

PCBs

Polychlorinated biphenyls, commonly referred to as PCBs, are the chlorinate derivatives of a class of aromatic organic compounds called biphenyls. Since their introduction into commercial use in 1929, PCBs have become widespread in the environment through vaporization into the atmosphere and spilling or dumping into water or onto land. Commercial products containing PCBs are used in the manufacture of capacitors and transformers and other closed and nonclosed electrical systems, as well as insecticides. Because PCBs do not easily disintegrate in the environment and accumulate in the fatty tissue and skin of man and other mammals, they pose a serious threat to the environment and human health (Sittig ed. 1980). The approximate half-life of PCBs in the soil is 4+ years.

PCBs have caused serious toxic effects in man and animals. The skin and liver are major sites of pathology with the gastrointestinal tract and nervous system also being targets. In addition, studies in animals suggest that some PCBs are carcinogenic and that they can enhance the carcinogenicity of other chemicals. Humans are exposed to PCBs through food, water, and air.

PCBs are currently not produced in the United States. Manufacturing of PCBs was banned in 1979 and all processing and distribution for commercial uses also ceased in 1979. The EPA has specific regulations covering certain exemptions to this ban and for the disposal of PCBs (Sittig ed. 1980; Frandsen pers. comm.).

From May 1981 to May 1982, West Point's digested, dewatered sludge contained 1.6 mg/kg of PCBs and Renton's raw, waste activated sludge contained 0.5 mg/kg of PCBs (Metro 1983a). PCBs in sludge come from both point and nonpoint sources. Point sources include solvent plants and improper storage and handling practices. The nonpoint sources are scattered residues in the environment which cannot be isolated (Cochran pers. comm.).

The EPA (1979c), through regulations 40 CFR 257, has established that any solid waste (e.g., sewage sludge) containing concentrations of PCBs greater than 10 mg/kg (dry weight) must be incorporated (by plowing or injection) below the soil surface if the site is to be used for producing animal feed. At 1.6 mg/kg, Metro sludge is well below that level.

Chlordane

Chlordane is a manmade cyclodiene insecticide which has been used extensively over the past 30 years for termite control, as an insecticide for homes and gardens, and as a control for soil insects. It has been detected at various concentration levels in ambient air, drinking water, rainwater, and soils. Also, because of its fat solubility, it readily accumulates in the tissues of organisms (Sittig ed. 1980). Chlordane is quite persistent in the environment and has an approximate half-life of 2-4 years (Dacre in Bitton et al. 1980). This insecticide is highly toxic to aquatic organisms, avian, and mammalian species.

The EPA banned the overall use of chlordane in 1978; however, certain uses are still permitted such as termite control and dipping of nonfood roots and tops for insect control (Frandsen pers. comm.).

When monitored from May 1981 to May 1982, neither West Point's digested, dewatered sludge nor Renton's raw, waste activated sludge contained any detectable amounts of chlordane (Metro 1983a).

DDT

DDT is a broad spectrum insecticide which has been used extensively throughout the United States for public health and agricultural programs. This insecticide has several properties that cause significant environmental and human health problems. DDT and its metabolites are toxicants with long-term persistence in soil and water; it is widely dispersed by erosion, runoff, and volatilization, and the low water solubility and high lipophilicity of DDT result in concentrated accumulation of DDT in the fat of wildlife and humans. DDT is acutely toxic to freshwater fish and invertebrates.

Humans are exposed to DDT primarily through ingestion of contaminated food. Air and water intake is generally negligible except in previously heavily sprayed agricultural areas where large amounts of residues may still be present. DDT is suspected to be a human carcinogen (Sittig ed. 1980).

The EPA banned the use of DDT in 1972. In certain emergency instances, EPA may grant permission to use DDT again for public health and vector control (Frandsen pers. comm.).

Neither West Point's digested, dewatered sludge nor Renton's raw, waste activated sludge contained any detectable amount of DDT during the sludge monitoring conducted from May 1981 to May 1982 (Metro 1983a).

Endrin

Endrin is a manmade cyclodiene pesticide. Of all the cyclodiene pesticides, endrin is the most toxic, but is also less persistent in the environment than DDT or dieldrin (U. S. HEW 1979). This pesticide has been predominately used to prevent lepidopteron larvae from attacking cotton crops in the southeastern and Mississippi delta states. Endrin is highly toxic to all animals regardless of the route of exposure. The primary toxic effect of acute exposure is on the central nervous system (Sittig ed. 1980). the approximate half-life of endrin in the soil is 4-8 years (Dacre in Bitton et al. 1980).

Humans are exposed to endrin through diet, inhalation, and dermal contact. Agricultural workers, home gardeners and other people involved in endrin manufacture and distribution are the most likely to be exposed to endrin. Quantitative data on endrin toxicity to humans are not available (Sittig ed. 1980).

The EPA banned the use of endrin in 1979. However, certain restricted uses of endrin are currently permitted (Frandsen pers. comm.).

Neither West Point's digested, dewatered sludge or Renton's raw, waste activated sludge contain any detectable amounts of endrin from May 1981 to May 1982 (Metro 1983a).

Lindane

Lindane is the common name for the insecticidally-active hexachlorocyclohexane. Hexachlorocylohexane is a broad spectrum insecticide. Lindane is used to control insects in a wide range of treatments including treatment of animals, buildings, humans for ectoparasites, clothes, water for mosquitoes, plants, seeds, and soil. The insecticide is slow to disintegrate in the soil (10 percent degradation after 6 weeks) and is acutely toxic.

Humans are exposed to lindane through ingestion of contaminated food, dermal contact, and inhalation. Lindane is suspected of being carcinogenic to humans (Sittig ed. 1980).

Lindane used in this country is currently imported. The EPA has not banned the use of this pesticide; however, it is under review for regulatory action (Frandsen pers. comm.).

Neither West Point's digested, dewatered sludge or Renton's raw, waste activated sludge contain any detectable amounts of lindane from May 1981 to May 1982 (Metro 1983a).

Methoxychlor

Methoxychlor is a synthetic organo-chlorine insecticide that is similar in structure to DDT. This insecticide is used on a wide range of insects that attack fruits, vegetables, shade trees, home gardens, forage crops, and livestock. Methoxychlor is generally applied directly to crops via ground or aerial spraying. Methoxychlor is generally considered a relatively safe pesticide with a low order of toxicity to humans and other warm blooded animals.

Human exposure to methoxychlor is through inhalation or ingestion of contaminated food. Methoxychlor does not readily accumulate in body tissues (U. S. HEW 1978c).

This pesticide is currently being manufactured and used in the United States. The EPA has not taken any action to ban its production and usage (Frandsen pers. comm.).

During sludge monitoring conducted from May 1981 to May 1982, neither West Point's digested, dewatered sludge nor Renton's raw, waste activated sludge contained detectable amounts of methoxychlor (Metro 1983a).

Toxaphene

Toxaphene is a broad spectrum, chlorinated hydrocarbon pesticide that is primarily used to control insects on agricultural crops, especially cotton. This pesticide readily accumulates and persists in living organisms and sediments (Sittig ed. 1980). The approximate half-life of toxaphene in the soil is 10 years (Dacre in Bitton et al. 1980). Toxaphene is not generally found in high concentration levels in water. However, it is highly toxic to many aquatic invertebrate and vertebrate species (Sittig ed. 1980).

Humans are exposed to toxaphene primarily through residues in air, water, and food (U. S. HEW 1979). Toxaphene is considered to be a likely human carcinogen and is known to cause toxic reactions in the body (Sittig ed. 1980).

The EPA banned the production of toxaphene and its subsequent use in November 1982. All existing supplies may be used until December 1986, after which time only certain uses will be exempt from the ban (Frandsen pers. comm).

Both West Point's digested, dewatered sludge and Renton's raw, waste activated sludge contain no detectable amounts of toxaphene (Metro 1983a).

2,4-D and 2,4,5-TP (Silvex)

2,4-D and 2,4,5-TP (Silvex) are chlorinated phenoxy acid herbicides that are used extensively for weed control. These herbicides are very potent even at low concentrations (American Public Health Association et al. 1976).

Humans are exposed to 2,4-D and 2,4,5-TP through ingestion of contaminated water, and food and direct exposure. Agricultural workers, pilots, mechanics, hand applicators, and other people involved in 2,4-D and 2,4,5-TP manufacture, distribution and application are the most likely to be exposed to these pesticides.

The EPA banned the use of 2,4,5-TP (Silvex) in 1979. However, certain restricted uses of 2,4,5-TP are currently permitted. EPA has not taken any action on the usage of 2,4-D (Frandsen pers. comm.).

Neither West Point's digested, dewatered sludge nor Renton's raw, waste activated sludge contain any detectable amounts of 2,4-D or 2,4,5-TP (Metro 1983a).

APPENDIX B

PROPERTIES OF FOREST SOILS

Introduction

The addition of sludge to forest soils is likely to alter a number of soil chemical properties and processes, including:

- pH
- Cation exchange capacity
- Mechanisms of cation movement
- Nitrogen cycling
- Heavy metal concentrations and mobility
- Organic toxins

pH

Soil pH is an important soil characteristic because it controls the availability and movement of plant nutrients and heavy metals as well as the actions of microorganisms. Most forest soils in western Washington have a pH between 4.5 and 6.0, while the pH of digested, dewatered sludge from local treatment plants averages about 7.4. This high pH results from ammonium produced metabolically during anaerobic degradation (Mayer, 1980).

Following application of sludge to forest land, the pH of the sludge begins to drop due to acidic throughfall and litterfall, formation of organic acids and nitrification (conversion of ammonium to nitrate) (Alexander, 1977). During that time, the pH of the soil underlying the sludge may increase slightly (Harris in Sopper and Kerr, 1979).

The rate of pH change in both the sludge and soil is highly variable, depending on climatic factors and litterfall rates. Edmonds and Mayer in Bledsoe (1981) reported a slight initial drop in sludge pH following a five inch summer application, but found that the pH remained well above soil pH for about one year. That high pH was reportedly due to slow decomposition and lack of leaching. In the four months following, the pH of the sludge dropped to a value below that of the underlying soil. Low sludge and surface soil pH are due to nitrification and displacement of acidic H+ ions by other cations introduced by the sludge (Edmonds and Cole, 1977).

Based on the results of the aforementioned research and the highly buffered nature of forest soils, it is unlikely that the small amount of sludge proposed for application to the Pilchuck site would have any long term effects on soil pH. Surface soils can expect a temporary increase in pH, followed by a pH decline with a final value near the original pH (Zasoski, pers. comm.).

Cation Exchange Capacity (CEC)

The CEC may be defined as the ability of a soil to adsorb cations and is expressed in millequivalents per 100 grams of soil. CEC is heavily dependent on soil pH as well as the type and quantity of clay minerals and organic matter. Those materials are usually negatively charged and provide exchange sites for cations. Because of a higher clay and organic matter content, surface soils generally have a higher CEC than do subsoils.

Sludge contains a great amount of organic matter and subsequently has a CEC well above that of the coniferous forest soils on which it would be applied. As the sludge decomposes, the CEC of the underlying soil is likely to increase. Edmonds and Cole (1977) reported that one year after the application of 10 centimeters of sludge to a gravelly outwash soil, the CEC of the soil had increased 30 percent over pretreatment levels. Following two years of sludge (3 percent solids) application Stednick and Wooldridge (Sopper and Kerr, 1979) found soil CEC increases of 31 percent, with the most dramatic increases in the A horizon. The authors also found no changes in the type or quantity of clay minerals in the soil and attributed CEC changes to increases in the amount or form of organic colloids.

The addition of sludge appears to significantly increase the number of exchange sites for cations. CEC increases following sludge applications on the Pilchuck sites would probably be less than the 30 percent reported by Edmonds and Cole (1977). Their results were based on a 10 centimeter application of sludge; approximately four times the amount of sludge scheduled for application to the Pilchuck sites.

The surface soil CEC of the Pilchuck sites is higher than that of the soils investigated by Edmonds and Cole (1977). The CEC of the surface layer of the Winston soil on the number 8 Pilchuck site, for example, is about 29 meq/100 (Table B-4), which is nearly three times the CEC of the site studied by Edmonds and Cole (1977). It is likely that sludge would cause a greater CEC increase in soils that possess a low initial CEC (Zasoski, pers. comm.).

Mechanisms for cation movement

Many of the nutrients required for plant growth occur as positively charged ions (cations). In western Washington coniferous forests, the cations are conservatively cycled with only a small percentage lost from the system via leaching. In order for cations to move through the soil profile, two things must be present:

1. a mobile anion to maintain electrical neutrality in transport
2. a cation to displace the migrating cation

Cation losses from forest systems are most often limited by the paucity of mobile anions (Johnson and Cole, 1980). In the coniferous forests of western Washington organic acids and bicarbonate ions appear to be the dominant mobile anion responsible for cation movement (Riekerk, 1978).

Sludge adds both the potentially limiting mobile anions and the replacement cations. Following applications of sludge, nitrate becomes the dominant anion responsible for cation transport (Edmonds and Cole, 1976). Sulfate and chloride anions introduced through sludge application play minor but significant roles in cation movement. White phosphate, another anion present in sludge, appears to play an insignificant role in cation leaching because it is rendered insoluble by iron oxides in the lower B horizon (Sopper and Kerr in Sopper and Kerr, 1979; Wiklander, 1975). Cations commonly lost via leaching include sodium, potassium, magnesium and calcium, with the greatest losses associated with calcium (Table B-1).

The following factors are likely to cause cation leaching rates to be greater on the Pack forest site (Table B-1) than on the Pilchuck sites:

1. Sludge depths at Pack forest were about four times those proposed for Pilchuck.
2. Pack forest soils were coarser textured which may allow greater cation leaching rates than the finer textured soils (Edmonds and Cole, 1977).
3. The trees on the Pack forest site were much older than those at the Pilchuck site. Older stands are known to uptake less nitrogen (the source of the dominant mobile anion) than do younger stands (Cole and Johnson in Heilman et al., 1979).

Nitrogen Cycling

In an unfertilized western Washington coniferous forest, nitrogen is conservatively cycled and often limits tree growth. The vast majority of nitrogen exists as organic nitrogen and other proteins which cannot be utilized by higher plants (Figure B-1).

TABLE B-1

Elemental concentrations (PPM) of C-Horizon leachates for the Pack Forest demonstration site (modified from Edmonds and Cole 1977)

	NH_4-N	NO_3-N	P	S	CL	Na	K	Ca	Mg
Control (no sludge)	0.02	0.10	0.03	1.4	4.8	2.5	0.9	31.2	0.8
10 cm sludge	0.16	19.30	0.06	1.5	49.6	9.9	2.6	52.5	14.5
Percent increase	700	19,200	100	7.1	933	296	189	68.3	1712.5

Assumes: Everett Soil series with a Douglas fir canopy.

A small percentage (about one percent) of this organic nitrogen is hydrolyzed by heterotrophic organisms through the processes of mineralization to ammonia (NH_3) and ammonium (NH_4+) (Heilman and Gessel, 1963). Oxidation of ammonium to nitrate (NO_3-) (nitrification) occurs slowly due to low soil pH and paucity of the nitrifying bacteria necessary to make the transformation. Competition for the small amounts of NO_3- is fierce, with bacteria utilizing most of this anion. The remainder is taken up by vegetation and only a small amount is leached from the soil.

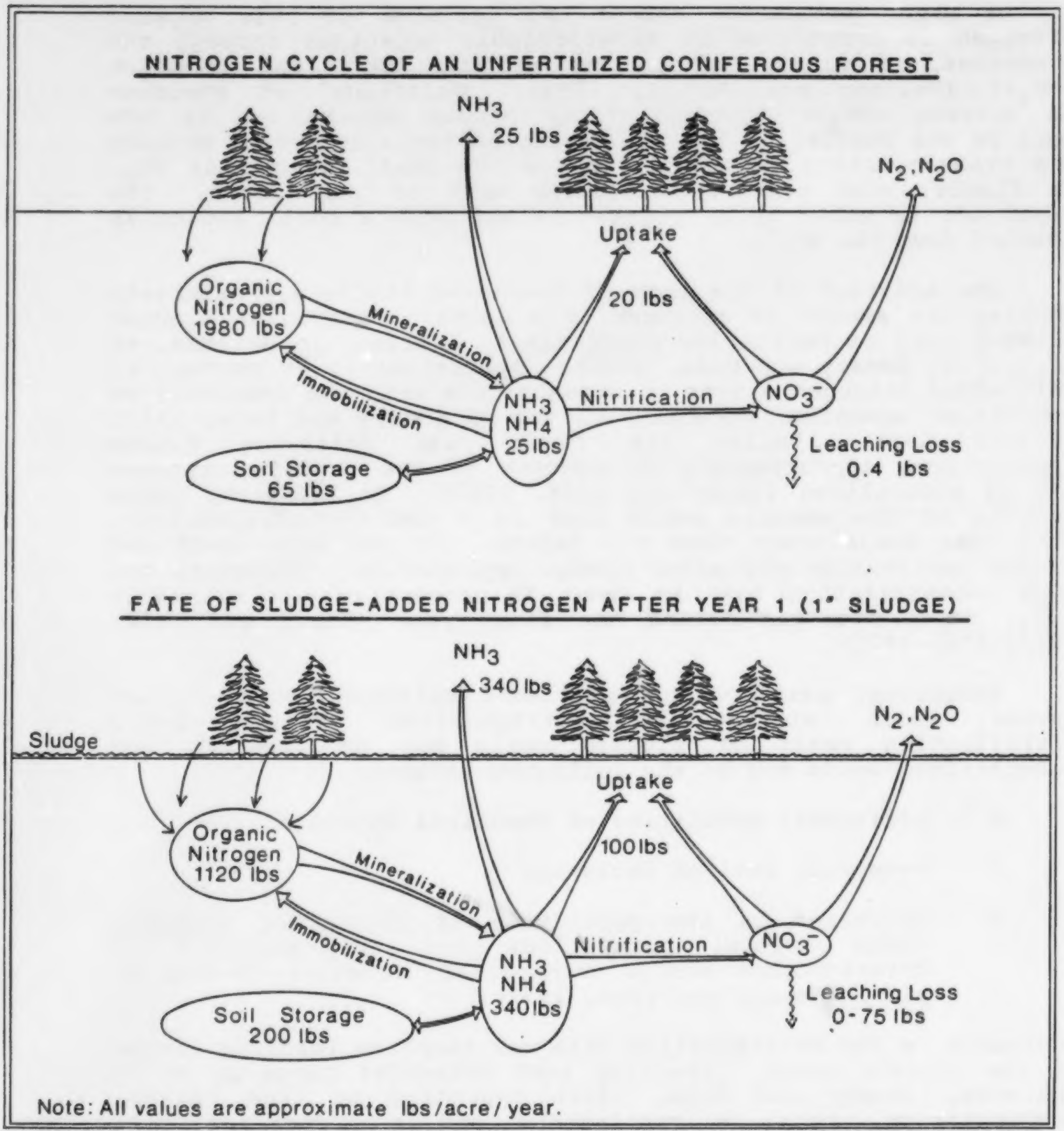
The addition of one inch of dewatered sludge approximately doubles the amount of nitrogen in a western Washington glacial outwash soil of medium low productivity (Heilman in Heilman, et al., 1979; Henery and Cole, 1983). Approximately 78 percent of this added nitrogen exists in organic form with the remainder as ammonia or ammonium, depending on the pH (Henry and Cole, 1983) (Figure B-1). During the first year following sludge application, approximately 20 percent of the organic nitrogen may be mineralized (Henry and Cole, 1983). In addition, large amounts of the ammonia would lost as a gas (volatilization). That loss would occur from the lagoon, (if one were used) and during application and after sludge application. Esitmates are that volatilization loss is about 50 percent of the available (NH_3, NH_4+) nitrogen during the first year (Henry and Cole, 1983; EPA, 1977).

Additional pathways for available nitrogen include plant uptake, soil storage or nitrigication (Figure B-1). Nitrification rates of sludged soils may be greater than unfertilized soils due to the following factors:

- additional quantities of ammonical nitrogen
- temporary soil pH increases
- increases in the population of nitrifying bacteria (both initial populations and the addition of heterotrophic sludge transported bacteria) (Brewer et al. in Sopper and Kerr, 1979).

Increases in the nitrigication rate may increase leaching losses of the nitrate anion. Leaching loss estimates range up to 75 lbs/acre, (Henry and Cole, 1983) depending on tree uptake, precipitation, bacteria populations and a number of soil variables.

The potential for nitrate leaching should decrease dramatically during the second year. Mineralization should decrease to about 3 percent of the total available nitrogen while uptake may increase to about 150 lbs/acre (Henry and Cole 1983). This would result in less nitrate available for leaching. A simplified nitrogen balance for years two, three and four following sludge application is presented in Table B-2.


NITROGEN CYCLE OF AN UNFERTILIZED CONIFEROUS FOREST
NH_3
25 lbs
N_2, N_2O
Uptake
20 lbs
Organic Nitrogen 1980 lbs
Mineralization
Immobilization
NH_3 NH_4 25 lbs
Nitrification
NO_3^-
Leaching Loss 0.4 lbs
Soil Storage 65 lbs
FATE OF SLUDGE-ADDED NITROGEN AFTER YEAR 1 (1" SLUDGE)
NH_3
340 lbs
Sludge
N_2, N_2O
Uptake
100 lbs
Organic Nitrogen 1120 lbs
Mineralization
Immobilization
NH_3 NH_4 340 lbs
Nitrification
NO_3^-
Leaching Loss 0-75 lbs
Soil Storage 200 lbs

Note: All values are approximate lbs/acre/year.

SOURCE: VALUES OBTAINED FROM COLE AND JOHNSON IN HEILMAN (1979) AND EDMONDS AND COLE (1982) FOR GRAVELLY OUTWASH AND A DOUGLAS FIR STAND.

FIGURE B-1

Nitrogen Cycles of Unfertilized Soil
(Conceptual Model , Not Actual Values)

Table B-2

Nitrogen Balance for Years Two, Three and Four Following a One-Inch Sludge Application To a Western Washington Coniferous Forest

Year Two

Available N (storage	200	pounds/acre
Mineralized N	+ 50	" "
Tree Uptake	-150	" "
Volatilized	0	" "
Leached	25	" "
	75	pounds/acre stored, 1000 pounds/acre organic-N remains

Year Three

Available N (storage	75	pounds/acre
Mineralized N	+ 30	" "
Uptake	-105	" "
Volatilized	0	" "
Leached	0	" "
	0	pounds/acre stored, 970 pounds/acre organic-N remains

Year Four

Available N (storage	0	pounds/acre
Mineralized N	+ 30	" "
Uptake	- 30	" "
	0	pounds/acre stored, 940 pounds/acre organic-N remains

From: Metro 1982d
All values are approximate

Heavy Metal Concentrations and Mobility

Unfertilized forest soils of western Washington contain low concentrations of heavy metals. Values such as those reported for the Pilchuck demonstration site (Tables B-3 and B-4) are typical for the region.

Digested sludge contains metal concentrations several times those found in the soil (Table B-3) and movement of those metals into the food chain or groundwater represents one of the major concerns regarding land disposal of sludge. Heavy metals may be essential plant nutrients, such as copper (Cu), zinc (Zn), manganese (Mn) and iron (Fe) or non-essential elements that can cause toxic reactions to plants and animals such as cadmium (Cd), nickel (Ni) and lead (Pb). Information concerning total allowable loadings of these metals can be found in DOE (1982). Table 2-3 gives heavy metal concentrations for Metro sludge.

In order for metals to move into vegetation or the groundwater, they must become soluble in the soil solution. Solubility depends on a number of factors including soil pH, CEC, amount of metal added, soil aeration and the metal in question.

Soil pH is the most important of these factors controlling metal solubility (EPA, 1977). Low soil pH's (below 6.5) can weaken the bounds between metals and complexing agents and increase the mobility of metals (EPA, 1977). The Environmental Protection Agency (EPA, 1979c) (DOE, 1982a) requires that the pH of soils used for food chain crops or animal feed be above 6.5 if sludge with a cadmium concentration over 2 mg/Kg is applied. Research with coarse forest soils however, has found that significant quantities of metals can be adsorbed by soils with a pH as low as 4.5 (Levine, 1975).

Heavy metals can be immobilized to varying degrees by oxides and organic matter. The relative efficiency of these compounds in immobilizing metals was identified by McLaren and Crawford (1973): Mn oxides organic matter Fe oxides clay minerals. In the coniferous forests of western Washington, organic matter, specifically fulvic acids, are important immobilizers of metals. These organo-metal complexes may however, migrate downward through the profile; especially in well aerated soils where channels of increased hydraulic conductivity may develop (Sidle and Kardos, 1977; Ugolini et al., 1977).

The properties of the metal such as valence state and ionic radius also determine the proficiency with which soil binds a metal. Copper and lead for example, are the most securely bound to organic soil constituents and have not been found to be mobile in the soil (Sidle and Kardos, 1977; Williams et al., 1980). Zinc, cadmium and nickel appear to be the most mobile heavy metals (Riekerk and Zasoski in Sooper and Kerr 1979; Williams et al., 1980).

Table B-3. Soil Samples Analysis of the Pilchuck Site

Parameter	Unit	Mean (n = 12)	Minimum	Maximum
Soil				
Organic-N	%, dry weight	0.312	0.52	1.31
NH_3-N	%, dry weight	.0061	.0009	.010
NO_2+NO_3-N	%, dry weight	.0060	.00051	.017
Total P	%, dry weight	.26	.086	.726
Ortho-P	%, dry weight	.023	.0052	.051
Total K	%, dry weight	.054	.035	.084
Total Solids	%, wet weight	77	56	88
Volatile Solids	%, dry weight	20	9	45
pH (saturated paste)	--	5.6	5.0	6.4
Cadmium	mg/kg	1.6	.9	2.3
Chromium	mg/kg	40	29	59
Copper	mg/kg	13	9	17
Mercury	mg/kg	.22	.14	.40
Nickel	mg/kg	45	25	65
Lead	mg/kg	21	9	42
Zinc	mg/kg	59	41	74
Bacteria (Geometric Means)				
Total Coliform	MPN/100 g wet weight	$.36 \times 10^5$	$.79 \times 10^3$	$.24 \times 10^7$
Fecal Coliform	MPN/100 g wet weight	$<.38 \times 10^2$	$<.2 \times 10^2$	$.24 \times 10^7$
Fecal Streptococci	MPN/100 g	$<.33 \times 10^3$	$<.2 \times 10^2$	$.7 \times 10^5$

Viruses - None detected in 12 soil samples tested (<2 PFU/100 g, wet weight)

Parasites - Giardia found in 2 of 8 soil samples tested (130/liter)

Chlorinated Organics - None detected in 8 soil samples tested

NOTE: MPN = Most probable number
PFU = Plaque forming unit
< = Less than

SOURCE: Metro 1983d.

Table B-4. Soil Samples Analysis Results of the Pilchuck Site

SAMPLE DESCRIPTION		Units		millimhos/cm	%	mg/kg			meq/100 grams Ab Dry Soil								mg/kg	Ab Dry Soil	Mg/Kg				
		Extractions	Sat Paste	Sat Extract	K2Cr2O7	Total Kjeldahl	KCl Ext	NaHCO3 Ext	NH4AC Extractable					Water Soluble						1N HNO3				
			pH	EC	Organic Matter	Nitrogen	NH3-N	PO4-P	CEC	Ca	Mg	K	Na	Ca	Mg	K	Na	NO3	S	Cd*	Cu	Ni	Pb	Zn
1	TP-1	0-3"	5.0	<0.2	2.9	1130	10	40	12.7	1.3	0.2	<0.1	<0.1					2		0.16	3.13	1.77	20.0	6.11
2		3-11"	4.8	<0.2	1.5	380	2	39	9.2	0.3	<0.1	<0.1	<0.1					3		<0.10	1.78	0.63	5.17	2.81
3		.-21"	5.1	<0.2	0.2	120	2	13	4.1	0.1	<0.1	<0.1	<0.1					2		<0.10	1.27	1.03	2.03	2.38
4		21-65"	5.3	<0.2	<0.1	65	2	6	2.2	0.2	<0.1	<0.1	<0.1					3		<0.10	1.06	0.80	1.11	0.40
5	TP-9	0-17"	4.9	<0.2	5.4	1450	3	17	16.5	<0.1	0.5	0.2	<0.1					3		<0.10	3.49	2.22	12.4	6.93
6		17-33"	4.9	<0.2	1.4	400	2	8	6.6	0.1	<0.1	0.1	<0.1					2		<0.10	2.92	1.36	4.73	3.47
7		33-72"	5.1	<0.2	0.1	80	3	7	1.3	<0.1	<0.1	<0.1	<0.1					4		<0.10	1.09	<0.50	<0.50	0.42
8	TP-13	0-5"	4.9	<0.2	0.7	330	4	21	2.4	0.5	<0.1	<0.1	<0.1					3		<0.10	2.02	2.53	3.19	4.89
9		5-14"	5.0	<0.2	<0.1	210	2	4	4.0	0.1	<0.1	<0.1	<0.1					3		<0.10	1.43	1.01	0.78	0.39
10		14-72"	5.2	<0.2	<0.1	<30	1	9	2.5	<0.1	<0.1	<0.1	<0.1					2		<0.10	1.37	0.92	<0.50	0.37
11	TP-17	0-21"	5.3	<0.2	2.9	720	2	14	16.3	2.8	0.3	<0.1	<0.1					3		<0.10	3.79	0.59	5.60	4.38
12		21-65"	5.1	<0.2	<0.1	60	1	6	2.9	<0.1	<0.1	<0.1	<0.1					3		<0.10	1.19	0.59	<0.50	0.23
13	TP-19	0-4"	4.6	<0.2	3.2	1600	3	56	28.7	1.3	0.7	0.2	<0.1					3		*0.16	5.10	4.96	5.50	7.23
14		4-17"	4.6	<0.2	3.6	840	3	65	26.6	0.8	<0.1	<0.1	<0.1					3		*0.39	8.19	8.06	6.81	6.09
15		17-32"	4.9	<0.2	0.1	170	1	18	7.2	0.3	<0.1	<0.1	<0.1					2		*0.16	1.83	3.49	2.03	1.41
16		32-72"	5.2	<0.2	<0.1	90	1	8	2.2	0.1	<0.1	<0.1	<0.1					3		<0.10	1.89	1.59	<0.50	0.36
17	TP-21	0-7"	4.4	<0.2	11.0	3340	5	33	29.1	1.2	0.7	0.2	<0.1					7		0.16	7.82	6.30	26.0	15.3
18		7-37"	4.7	<0.2	1.0	540	4	15	9.6	0.4	<0.1	<0.1	<0.1					4		<0.10	2.79	1.00	2.66	3.77
19																								
20																								

* High values were obtained when first tested, suspected glassware contamination, retested samples again except TP-19 lacked sufficient sample. The second set of results proved our glassware was contaminated, thus TP-19 Cd concentration maybe excessively high.

SOURCE: Metro 1983d.

In general, researchers have not found metals introduced by sludge to move below the top few inches of soil. Parker et al., (1978) reported that over 95 percent of the added Pb, Cu, Zn and Cd remained within 25 cm of the surface. Williams et al. (1980) found that concentrations of Pb, Cu, Zn, Cd, chromium (Cr) and mercury (Hg) reached background levels 10 cm below the sludge. Locally, Henry and Cole (1983) found extractable metal levels slightly above control levels at the 80 cm depth. These higher levels did not, however, represent a significant increase over control levels (Henry and Cole 1983).

Total metal accumulation following extended sludge and wastewater application has also been studied. Andersson and Nilsson (1972) reported that in 12 years of sludge application to agricultural land, nearly all of the Mn, Zn, Cu, Nr, Pb, Cd, Cr, Hg, arsenic, selenium and cobalt remained in the top 20 cm of soil, with only small amounts taken up by vegetation or leached from the system.

Organic Toxins

Sludge may contain trace amounts of a number of toxic organic chemicals. These chemicals include a number of chlorinated hydrocarbons and poly chlorinated biphenyls (PCBs). A complete list of these compounds and their levels in Metro sludge are found in Appendix A. Research on the behavior of these toxins in the environment is relatively incomplete.

Land application of sludge exposes the organic toxins to the following processes:

- volatilization
- plant uptake
- runoff in surface water
- movement into the groundwater
- adsorption by soil constituents
- degradation by microbial or photochemical action

Two factors favor the retention of the toxins in the upper soil layers: the low water solubility of toxins in water and the strong adsorption by surface soils (Darce in Bitton et al., 1980). Bailey and White (1970) found most toxins were adsorbed in the surface soil, with only a few reaching depths of 30-60 centimeters. Soil agents responsible for adsorption include organic matter, metal oxides and clays (Lichtenstein, 1971). The effectiveness of the adsorption depends on the number of functional groups, which include phenolic and carboxyl groups, amines and amides. Organic matter contains a large number of these groups, and therefore, great adsorptive capabilities.

Retention of the chemicals in the surface soil layer increases the possibility of volatilization or degradation. Volatilization of these chemicals occurs readily only at the soil surface and may involve only a small percentage of the amount applied (Lichtenstein, 1971). Volatilization rates vary, depending on the molecule and a number of soil and atmospheric conditions, but the insecticide aldrin appears to be one of the most volatile (Lichtenstein, 1971).

Degradation may occur either through microbial or photochemical action. Although microbial transformations are slow, some bacteria and fungi are capable of degrading the complex molecules into less toxic forms (Menzie, 1972). Ultraviolet irradiation is capable of transforming the insecticide dieldrin under certain conditions (Menzie, 1972).

In general, plants do not uptake large quantities of organic toxins (Pahren et al., 1979). This is due to the large size of the molecules and their low water solubility. Moza et al. (1979) found very low uptake rates of PCBs by spruce trees (Picea abies). Certain root crops however, may absorb organic toxins (Lichtenstein, 1971).

Appendix C

Silvicultural History Pilchuck Sludge Application Sites

The following information pertains to the silvicultural history of the Pilchuck Demonstration Sites:

Northern Site

1970 - site scarified

1971 - site planted to 1,700 trees/acre Douglas-fir

1977-1979 - harvest of a portion of the stand for Christmas trees

1980 - precommercial thinning to 350-400 stems/acre

1982 - aerial spraying with bravo 500 fungicide for Swiss Needle cast fungus

Southern Portion of Northern Site

1976 - site scarified

1976-1977 - site planted 600 trees/acre Douglas-fir

1978 - foliar aerial spray with 2-4D and 2-4-5T herbicide

Southern Site

1959 - site planted 500 stems/acre Douglas-fir

1963, 1965 - site interplanted with Douglas-fir due to mortality

1969 - foliar aerial spray with 2-4D

1979 - precommercial thin to 350 stems/acre

1981 - commercial thin to 300 stems/acre

Appendix D

Endangered and Threatened Species - Pilchuck Tree Farm Demonstration Site

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JOHN SPELLMAN
Governor

FRANK LOCKARD
Director

STATE OF WASHINGTON
DEPARTMENT OF GAME
600 North Capitol Way, GJ-11 • Olympia, Washington 98504 • (206) 753-5700

December 22, 1982

Jones and Stokes Assoc. Inc.
1802 136th Place N.E.
Bellevue, WA 98005

SUBJECT: Pilchuck Project Site

Dear Mr. Denman:

We have completed a review of the Natural Heritage Data Base for information on significant natural features in the study area. At this time we do not have information on special animal species in the immediate area. Since information is being added to the files daily, a search at some later date may be worthwhile. Please keep this in mind when long-term project planning is involved.

This response is not to be construed as a complete inventory of the project area and does not eliminate the need or responsibility to conduct more thorough research. Data in the Natural Heritage Data Base are limited to significant observations of species of concern only. Significant observations are primarily comprised of breeding site data, but depending upon the species, wintering areas and regular concentrations are also entered. For some particularly rare or secretive species, observations of individuals are considered sufficiently significant for data entry.

If your office should publish or distribute any of the information presented here, please cite the Natural Heritage Data System as follows:

Natural Heritage Data System
Department of Natural Resources and
Department of Game - Nongame Program
c/o The Evergreen State College
3109 Seminar Building, TA-00
Olympia, Washington 98505

I hope this presentation will be useful to you. If you have further questions or concerns, please feel free to contact me at (206) 754-1449 or SCAN 8-235-1449.

Very truly yours,

THE DEPARTMENT OF GAME

Kelly R. McAllister

Kelly R. McAllister
Nongame Wildlife Program

KRM:hl

Department of Natural Resources
OLYMPIA, WASHINGTON
98504

BRIAN BOYLE
Commissioner of Public Lands

WASHINGTON NATURAL HERITAGE PROGRAM
3111 Seminar Building (SE 3109)
The Evergreen State College
Olympia, Washington 98505

December 20, 1982

Mr. Robert A Denman
Jones and Stokes Associates, Incorporated
1802-136th Place N.E.
Bellevue, Washington 98005

Subject: Pilchuck project site

Dear Mr. Denman:

We have completed a search of the Natural Heritage Data System for your study area. At this time we do not have data on special plant species or high quality native plant communities near the area you specified. Information on special animal species will be provided, under separate cover, by the Washington Department of Game, Nongame Program.

Please be aware that the Data System is not exhaustive. There may be special plants or native plant communities occurring in your study area that we do not yet know about. Therefore, this information is not to be taken as a complete inventory of the project area and does not eliminate the need or responsiblity to conduct more thorough research.

Please cite the Natural Heritage Data System, as follows if this letter is referenced in publications or correspondence by your office.

> Natural Heritage Data System, 1981.
> Washington Natural Heritage Program and Washington
> Department of Game, Nongame Program. Mail Stop SE 3109,
> The Evergreen State College, Olympia, WA 98505.

I hope this information will be useful to you. Please feel free to contact me at (206) 753-2449 (SCAN: 8-234-2449), if you have any further questions.

Sincerely,

Elise Augenstein

Elise Augenstein
Data Manager/Botanist

EA/cd

Equal Opportunity/Affirmative Action Employer

ONES & STOKES ASSOCIATES, INC. / 1802 136TH PLACE, NE / BELLEVUE, WA 98005 206/641-3982

December 14, 1982

Kelly McAllister
Washington Department of Game,
Nongame Program
Evergreen State College
3109 Seminar Building
Olympia, WA 98505

Dear Mr. McAllister:

Would you please do an inventory search to determine if there are any rare and/or endangered animal species present on the Pilchuck project site. The site is located north of Arlington, T32N, R5E sections 23,24, 25,26,35,36 and R6E sections 19,30. A map showing the project site is enclosed.

The bill for the search should be sent to:

Jones & Stokes Associates, Inc.
1802 136th Place, N.E.
Bellevue, WA 98005

If you need any further information, please feel free to contact me at 641-3982. Thank you for your cooperation.

Sincerely,

Robert A Denman

Robert A. Denman

RAD/as
Enclosure

JONES & STOKES ASSOCIATES, INC. / 1802 136TH PLACE, NE / BELLEVUE, WA 98005 206/641-3982

December 14, 1982

David Mladenoff
Natural Heritage Program
3111 Seminar Building
Evergreen State College
Olympia, WA 98505

Dear Mr. Mladenoff:

Would you please do an inventory search to determine if there are any rare and/or endangered plant species present on the Pilchuck project site. The site is located north of Arlington, T32N, R5E sections 23,24, 25,26,35,36 and R6E sections 19,30. A map showing the project site is enclosed.

The bill for the search should be sent to:

Jones & Stokes Associates, Inc.
1802 136th Place, N.E.
Bellevue, WA 98005

If you need any further information, please feel free to contact me at 641-3982. Thank you for your cooperation.

Sincerely,

Robert A Denman

Robert A. Denman

RAD/as
Enclosure

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

M/S 443

Mr. Joseph Blum
U. S. Fish and Wildlife Service
Endangered Species Team
2625 Parkmont Lane
Olympia, Washington 98502

Dear Mr. Blum:

In accordance with Section 7 (c) of the Endangered Species Act of 1973, we are requesting information on the existence of endangered or threatened wildlife species or critical habitats in the vicinity of Arlington, Washington.

The Environmental Protection Agency is preparing an Environmental Impact Statement on a long-range sludge management plan for the Municipality of Metropolitan Seattle (Metro). Included in the analysis is a proposed demonstration project at the Pilchuck Tree Farm near Arlington. A brief project description and maps are enclosed.

If you need any further information, please do not hesitate to contact me at (206) 442-1834.

Sincerely,

Kathryn M. Davidson
Project Monitor

Enclosure

March 3 1849

United States Department of the Interior

FISH AND WILDLIFE SERVICE

Endangered Species
2625 Parkmont Lane S.W., B-2
Olympia, WA 98502

February 15, 1983

Ms. Kathryn M. Davidson
Project Monitor
Environmental Protection Agency
1200 Sixth Avenue
Seattle, Washington 98101

Refer to: 1-3-83-SP-128
Your ref: M/S 443

Dear Ms. Davidson:

As requested by your letter, dated January 12, 1983, I have attached a list of endangered and threatened species (Attachment A) that may be present in the area of the proposed Sludge Management Demonstration Project - Pilchunck Tree Farm, Snohomish County, Washington. The list fulfills the requirement of the Fish and Wildlife Service under Section 7(c) of the Endangered Species Act of 1973, 16 U.S.C. 1531, et seq. Your Endangered Species Act requirements are outlined in Attachment B.

Should your biological assessment determine that a listed species is likely to be affected (adversely or beneficially) by the project, your agency should request formal Section 7 consultation through this office.

Even if your biological assessment shows a "no effect" situation, we would appreciate receiving a copy of your assessment for our information. If you have any additional questions regarding your responsibilities under the Act, please contact Mr. Jim Bottorff, Endangered Species Team Leader, (206) 753-9444, FTS 434-9444 at the following address:

U.S Fish and Wildlife Service
Endangered Species Team
2625 Parkmont Lane S.W., Bldg. B-2
Olympia, WA 98502

RECEIVED
FEB 14 1983
ENVIRONMENTAL EVALUATION
BRANCH

Your interest in endangered species is appreciated.

Sincerely,

Jim A. Bottorff
Endangered Species Team Leader

Attachments

cc: RO (AFA/SE)
ES, Olympia
WDOG, Non-Game Program
WNHP

LISTED AND PROPOSED ENDANGERED AND THREATENED SPECIES AND CANDIDATE SPECIES THAT MAY OCCUR WITHIN THE AREA OF THE PROPOSED SLUDGE MANAGEMENT DEMONSTRATION PROJECT - PILCHUCK TREE FARM, SNOHOMISH COUNTY, WASHINGTON

1-3-83-SP-128
Your ref: M/S 443

LISTED:

Bald Eagle (Haliaeetus leucocephalus) - wintering concentration of eagles found along N. Fork Stillaguamish River near and downstream from the project area. Major concerns are:

1. Loss of streamside habitat - perch sites
2. Disruption of habitat and eagle activity during construction and operation of project facilities
3. Contamination of eagle prey items downstream of project area.

PROPOSED:

None

CANDIDATE:

None

Attachment A

FEDERAL AGENCIES' RESPONSIBILITIES UNDER SECTIONS 7(a) and (c) OF THE ENDANGERED SPECIES ACT

SECTION 7(a) - Consultation/Conference

Requires: 1) Federal agencies to utilize their authorities to carry out programs to conserve endangered and threatened species;

2) Consultation with FWS when a Federal action may affect a listed endangered or threatened species to insure that any action authorized, funded or carried out by a Federal agency is not likely to jeopardize the continued existence of listed species or result in the destruction or adverse modification of Critical Habitat. The process is initiated by the Federal agency after they have determined if their action may affect (adversely or beneficially) a listed species; and

3) Conference with FWS when a Federal action is likely to jeopardize the continued existence of a proposed species or result in destruction or adverse modification of proposed Critical Habitat.

SECTION 7(c) - Biological Assessment for Construction Projects

Requires Federal agencies or their designees to prepare Biological Assessment (BA) for construction projects[1/] only. The purpose of the BA is to identify any proposed and/or listed species which are/is likely to be affected by a construction project. The process is initiated by a Federal agency in requesting a list of proposed and listed threatened and endangered species (List attached). The BA should be completed within 180 days after its initiation (or within such a time period as is mutually agreeable). If the BA is not initiated within 90 days of receipt of the species list, please verify the accuracy of the list with our Service. No irreversible commitment of resources is to be made during the BA process which would result in violation of the requirements under Section 7(a) of the Act. Planning, design, and administrative actions may be taken; however, no construction may begin.

To complete the BA, your agency or its designee should: (1) conduct an onsite inspection of the area to be affected by the proposal which may include a detailed survey of the area to determine if the species is present and whether suitable habitat exists for either expanding the existing population for potential reintroduction of the species; (2) review literature and scientific data to determine species distribution, habitat needs, and other biological requirements; (3) interview experts including those within FWS, National Marine Fisheries Service, State conservation departments, universities and others who may have data not yet published in scientific literature; (4) review and analyze the effects of the proposal on the species in terms of individuals and populations, including consideration of cumulative effects of the proposal on the species and its habitat; (5) analyze alternative actions that may provide conservation measures; and (6) prepare a report documenting the results, including a discussion of study methods used, any problems encountered, and other relevant information. Upon completion, the report should be forwarded to our Area Manager.

[1/] "Construction Project" means any major Federal Action which significantly affects the quality of the human environment (requiring an EIS) designed primarily to result in the building or erection of man-made structures such as dams, buildings, roads, pipelines, channels, and the like. This includes Federal actions such as permits, grants, licenses, or other forms of Federal authorization or approval which may result in construction.

ATTACHMENT B

Appendix E

Cultural Resources Pilchuck Tree Farm Demonstration Site

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ONES & STOKES ASSOCIATES, INC. / 1802 136TH PLACE, NE / BELLEVUE, WA 98005 206/641-3982

January 10, 1983

Dr. Robert Whitlam
Office of Archaeology and Historic Preservation
111 West 21st Avenue, KL - 11
Olympia, WA 98504

Dear Dr. Whitlam:

Subject: Environmental Impact Statement (EIS)
Metro Sludge Management Plan

During November, 1982, I spoke with you briefly about needs to conduct an archaeological survey of proposed sludge application sites in Arlington, Washington.

The Municipality of Metropolitan Seattle (Metro) is proposing to initiate a sludge application demonstration project on 72 acres of land on the Pilchuck Tree Farm, Arlington, Washington. Jones & Stokes Associates, Inc. is contractor to the U. S. Environmental Protection Agency for the preparation of an EIS on Metro's long-range sludge management plan. As a first phase of that plan, Metro desires to demonstrate the spray application of liquid sludge onto forest lands.

I have attached maps showing the location of the 72 acre site and a description of the proposed sludge application program. The only possible ground-disturbing activity as a part of the project would be associated with the construction of a sludge storage lagoon.

At your earliest convenience I would like to know if a survey or cultural resources report will be necessary and if so required, could that task be accomplished during the design stage of the project.

If you are in need of any additional information, please do not hesitate to contact me.

Sincerely,

Jonathan H. Ives

cc: K. Davidson, U. S. EPA/Environmental Evaluation Branch

JOHN SPELLMAN
Governor

JACOB THOMAS
Director

STATE OF WASHINGTON
OFFICE OF ARCHAEOLOGY AND HISTORIC PRESERVATION
111 West Twenty-First Avenue, KL-11 • Olympia, Washington 98504 • (206) 753-4011

January 14, 1983

Mr. Jonothan H. Ives
Jones & Stokes Associates, Inc.
1802 136th Place N.E.
Bellevue, WA 98005

Log Reference: 367-C-KI-03

Re: Metro Sludge Management Plan

Dear Mr. Ives:

We have reviewed the materials forwarded to us for the above referenced project. Based on the results of our records searches, consultations, and the materials provided for our review, we recommend professional cultural resource surveys of the project area be conducted prior to further action.

The above comments are based on the information available at the time of this review. Should additional information become available, our assessment may be revised. Please indicate the log reference number noted above in further communications concerning this project. A copy of these comments should be included in subsequent environmental documents.

Sincerely,

Robert G. Whitlam, Ph.D.
Archaeologist

dj
Enclosure

CULTURAL RESOURCE ASSESSMENT PROPOSED SLUDGE FACILITIES AT THE PILCHUCK TREE FARM, ARLINGTON, SNOHOMISH COUNTY, WASHINGTON

by Carol Kielusiak

Submitted to

Jones & Stokes Associates

Office of Public Archaeology
Institute for Environmental Studies
University of Washington

Seattle

February 1983

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PROJECT LOCATION

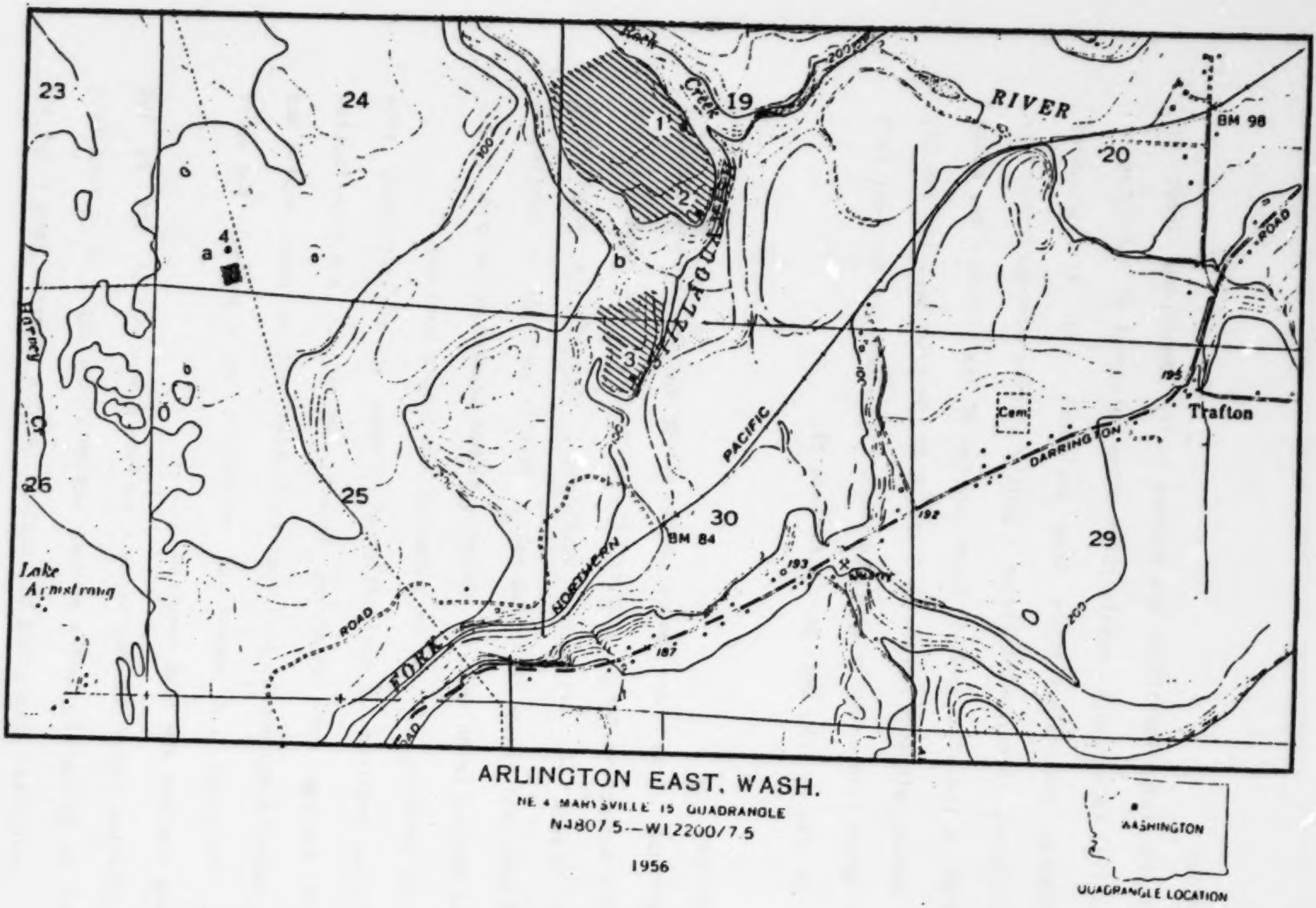
The proposed sludge facilities are located in the Armstrong Tract of the Pilchuck Tree Farm, approximately three miles northeast of Arlington in Snohomish County. The present study area includes: (1) the proposed sludge application sites, which lie on a gently sloping plateau bounded by the North Fork of the Stillaguamish River and two of its tributaries, Kunze and Rock Creeks, situated mainly in T 32N, R 6E, SW 1/4, Sec. 19, and (2) the sludge lagoon site which is situated about 1.6 kilometers due west in T 32N, R 5E, SW 1/4, SW 1/4, Sec. 24, W.M. (Map 1).

PROPOSED ACTIONS

The Pilchuck Tree Farm demonstration sludge application project is a joint effort to improve forest productivity of 70 acres (28 Hectares) of land near Bryant and Arlington, Washington, through the addition of dewatered municipal sludge to forest soil. This is part of a continuing effort to improve techniques for managing timber production on over 13,000 acres (5,260 Hectares) of land in Snohomish and Skagit Counties.

Facilities required for application of sludge at the Pilchuck site include a storage and rehandling lagoon, an access and distribution network, security equipment, personnel facilities, and equipment repair and cleaning facilities. A number of monitoring wells and soil and water monitoring stations are also required.

The proposed lagoon has approximate surface dimensions of 135 by 190 feet (41 by 58 meters), and a maximum design sludge depth of 15 feet (4.5 meters). Additional area would be required for the external berm slope and


23
24
19
20
25
30
29
26
RIVER
Creek
STILLAGUAMISH
1
2
3
4
a
b
BM 98
BM 84
Trafton
Cem
DARRINGTON
PACIFIC
NORTHERN
FORK
ROAD
Lake Armstrong
Harvey Cr
ARLINGTON EAST, WASH.
NE 4 MARYSVILLE 15 QUADRANGLE
N4807.5—W12200/7.5
1956
WASHINGTON
QUADRANGLE LOCATION

MAP 1. Vicinity map of project area showing locations of isolated finds (numbered) in relation to (a) lagoon site and (b) application area.

for a roadway around the lagoon. A 6-foot chain link fence would be provided for access control. Other features include an access and dumping area for long-haul trucks, a rehandling area for loading the application vehicles, maintenance access, erosion protection, a leachate collection system, and an adjacent monitoring well.

ENVIRONMENTAL SETTING

The project area is situated on a tract of land which is bordered by the foothills of the North Cascades Mountains on the north, and the North Fork of the Stillaguamish River to the south. The topography is characterized by plateaus bordered by steep gorges incised by the Stillaguamish River and tributary creeks.

The geology of the area consists of glacial sediments, deposited during the most recent glaciation (the Vashon), which overlie bedrock. Soil studies recently conducted by CH2M Hill (U.S.E.P.A. 1983) indicate that soils in the project area consist of Ragner Series (sandy loam overlaying a loamy sand), except on the bluff situated between Kunze and Rock Creeks, where Winston Series (loam above a gravelly sand) prevails.

The natural patterns of vegetation which are characteristic of this area of the Puget Sound Lowlands have been somewhat altered in the project area by silvicultural activities. A brief history of these activities, in a portion of the project area, is summarized below.

The northern portion of the northernmost sludge application area was scarified in 1970 and planted to 1700 Douglas Fir trees per acre the following year. From 1977-1979, a portion of the stand was harvested for Christmas trees and in 1980, the stand was precommercially thinned to

350-400 stems per acre. The southern portion of this site was scarified in 1976 and, in 1976 and 1977, 600 Douglas Fir trees were planted per acre.

The sludge applications site, which lies to the south, was planted with 500 Douglas Fir stems per acre in 1959. In 1963 and 1965 this area was interplanted with additional trees because of mortality. The stand was precommercially thinned to 350 stems per acre in 1979 and two years later was commercially thinned to 300 stems per acre (U.S.E.P.A. 1983).

Natural vegetation has reclaimed the area in varying degrees so that an occasional cedar (Thuja plicata) and alder (Alnus rubra) can be found among the stands of Douglas Fir. The understory, which is quite dense in much of the study area, includes native blackberry (Rubus ursinus), bracken (Pteridium aquilinum), sword fern (Polystichum munitum), Oregon grape (Berberis nervosa), salmon berry (Rubus spectabilis), salal (Gaultheria shallon), devil's club (Oplopanax horridum), etc.

CULTURAL SETTING

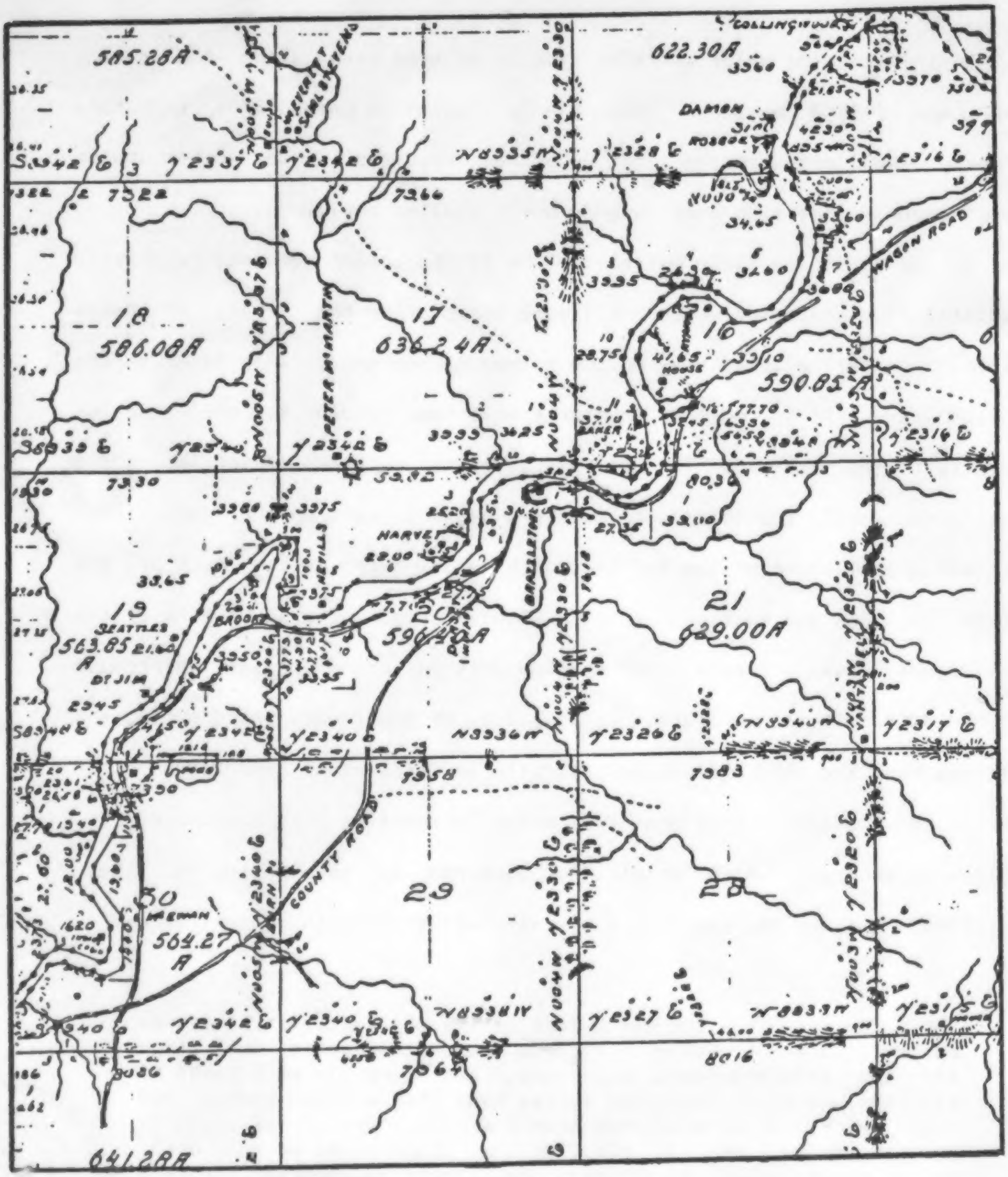
The following ethnographic descriptin is primarily taken from Lane (1973). The project area is situated within the territory occupied ethnographically by the Stillaguamish Indians. Relatively little documentary information is available regarding their traditional lifeways, but from the limited evidence that is available, it is obvious that the Stillaguamish were skilled fishermen and canoe handlers who relied on the resources of the river and its tributary streams for their staple food. Salmon and steelhead were taken with a variety of implements, including harpoons, weirs and traps. The catch was eaten fresh or it was smoked or dried for winter use. Hunting is also mentioned as a subsistence activity, as is berry picking.

Distribution of major villages appears to have been along the river, and Lane (1973) mentions that the Stillaguamish camped along tributary creeks. Dwellings were the split cedar bark type typical of other Puget Sound groups; they also used roughly built smaller dwellings.

In contrast to their neighbors, the Stillaguamish remained relatively isolated from white influence until some years after the Treaty of Point Elliot. After a brief stay on the Holmes Harbor and Tulalip Reservations in the years 1855-56, most of them were able to return to their native territory and continue in their traditional patterns of settlement and subsistence until the 1870s when settlers began to take up the land.

While settlement of the Stillaguamish Valley began at the mouth of the river in 1864 and continued to push slowly upriver, the North Fork of the Stillaguamish was not considered particularly desirable for farming because of the difficulty of navigation in this area of the river. Apparently, the Indians were the only ones to successfully pole the river, and were often hired to transport settlers and bring in supplies from Standwood. The following excerpt, which originally appeared in the Arlington Times, describes, quite picturesquely, early settlement along the upper river:

> Until the year 1884 the North Fork of the Stillaguamish River was called 'Starve-Out Valley,' for the reason that up to that time all the settlers were bachelors, who went in with packs of blankets and provisions, and by the time that a shake shanty had been built, a few trees had been cut, the 'last bit of bacon in the pan, fried,' the last batch of sour dough baked on the coals in a cedar board fireplace, the packstrap settler hailed a passing Siwash canoe and went to Stanwood for another pack of supplies. Many never returned and the places were taken by others, who in time abandoned them. And the hopeful bachelor came and the hungry bachelor went, until a woman demonstrated that a human being could not only exist on the products of the North Fork, but could live there for eighteen years and grow stouter all the time (Whitfield 1926:517).


585.28A
622.30A
COLLINGWOOD
DAMON
WAGON ROAD
18
586.08A
17
636.24A
16
590.85A
HOUSE
BAKER
HARVEY
BROOKS
19
SEATTLES
563.85 A
DR JIM
20
21
629.00A
COUNTY ROAD
29
28
30
564.27 A
641.28A

MAP 2. 1890 GLO Plat Map of project vicinity.

The woman referred to is Mrs. Collingwood, whose party passed the proposed project area in 1884, on their way to settle their claim. As they came to the stretch of the Stillaguamish River which borders the present study area, they stopped and "pitched their tents at the McEwan place, three miles up the North Fork, and took possession of an abandoned bachelor cabin...(Whitfield 1926:520). The McEwan claim is located on the 1890 General Land Office Map (GLO 1890) on the east side of the river, below the proposed sludge application site (see Map 2).

By the early 1890s, the general area was well settled and a number of post offices and towns, such as Trafton, Oso, and Bryant were established. Present day Arlington is the result of consolidation of Haller City, platted in 1883 and Arlington (Phillips 1978:8-9). The plat of Arlington was filed on March 15, 1890, and was incorporated in 1903. Arlington soon became the commercial and industrial center of this dairying, farming, and timber area (Whitfield 1926:537).

The extension of the Northern Pacific Railroad to include the Arlington-Darrington Branch was completed about the end of May 1901, an event which caused a population influx and provided for increased interest in the timber and agricultural industries in this vicinity (Local Committee of Pioneers 1906:301, 362).

A survey conducted by the General Land Office after the coming of the railroad reveals that the portion of the study area proposed for sludge application was, at that time, claimed by George W. Kunze, hence the probable origin of the name Kunze Creek. The application area also touches a portion of what was the C. H. Cobb and Palmer Land and Inv. Co. and part of the claim of James Seanty, "Indian", as well as a small portion of the Wisconsin Timber Co. Land.

The proposed sludge lagoon site was then Port Blakely Mill Company property. The present Darrington road, which is located about a mile south of the study area, appears to follow the route of an old wagon road (Anderson Map Co. 1910).

The area today continues to maintain farms and dairies in the alluvial plains of the river and the study area itself has been incorporated into the Pilchuck Tree Farm.

RESULTS OF LITERATURE/ARCHIVAL REVIEW

The records on file at the State Office of Archaeology and Historic Preservation and at the Office of Public Archaeology were consulted for information on known cultural resources within the study area. There are no properties within the study area which are currently listed, or considered to be eligible for listing, on either the State or National Registers of Historic Places.

The Washington State Archaeological Site Survey Records locate the nearest recorded archaeological site (45-SN-63) about five kilometers to the south, between Jim Creek and the Stillaguamish River. Apparently, while a number of cultural resource studies have been conducted on the South Fork of the Stillaguamish (e.g., Thomson 1961; Kidd 1964; and sites recorded by Mattson in 1974, 1980 and by Onat in 1979), none of them have extended onto the North Fork. These investigations reveal that the South Fork area contains a high density of archaeological sites which yield artifact assemblages assignable to the controversial "Olcott" phase, possibly dating to an early period. Many of these sites are located on terraces, above major rivers (Stilson and Chatters 1981:14-21). The physiographic setting of the proposed study application area suggests the possibility for the presence of such remains.

Ethnographic literature review revealed that the nearest recorded villages in the study area are near Trafton (T 32N, R 6E, Sec. 20 and around Arlington (T 31N, R 5E, Sec. 21), and, in 1952, a tripod weir was noted about four miles above Arlington, on the North Fork of the Stillaguamish River (Lane 1973).

Perusal of General Land Office 1890 plat maps show that early settlements were situated along the banks of the river, where rich alluvial soil was available for farming, rather than on the high terraces of the study area (Map 2).

ON-SITE ASSESSMENT

Field reconnaissance of the proposed sludge lagoon location and sludge application sites was conducted on February 10 and 11, 1983 by Ms Joan Robinson and Ms Carol Kielusiak, Staff Archaeologists at the University of Washington's Office of Public Archaeology. Survey tactics varied in different portions of the study area, depending on access, extent of ground visibility, and extent of previous ground disturbance. Greatest efforts were expended on those portions considered to be especially site sensitive.

Reconnaissance of the proposed sludge application sites consisted of walking the edges of the bluffs above Rock Creek, Kunze Creek and the Stillaguamish River. These bluff edges had remained relatively undisturbed as evidenced by the presence of old growth timber and absence of recent Douglas Fir plantings. It does appear that the soil had been disturbed in some areas, possibly as a result of scarification. Understory vegetation was dense in some areas, and ground cover included grasses, moss and duff. Slash piles also littered the way, but traverse was possible. Due to the high potential for archaeological remains in these areas, every five to ten meters surveyors cleared an area to soil, measuring at least 50 X 50 centimeters. Ground visibility was also provided by animal trails, uprooted trees, and animal burrows.

The all-weather road which bisects the application sites was also checked for cultural remains. Several attempts were then made to walk transects parallelling the road in the forested area. However, it soon became apparent that traverse through the dense undergrowth was impossible in some places and, in others, both time-consuming and unproductive.

Survey in the interior area of these plateaus was limited, therefore, to walking existing paths, trails and access roads which bisect the areas, generally at an angle perpendicular to the all-weather road. A total of ten of these were walked, six in the northern area and four in the southern area.

The proposed sludge lagoon site had not yet been staked so its proposed location was determined as nearly as possible from the project map. The area surveyed was a portion of a triangular shaped piece of property, bordered on the east by the powerline and on the west by Access Road 20. The southern limit was 160 meters north of the Road 20/21 fork and extended, in a northerly direction, for 192 meters.

Survey strategy consisted of walking 10 meter transects in a NW/SE direction until the area was covered, checking all available ground exposures and clearing a 50 X 50 centimeter section of ground cover approximately every 10 meters. The history of silvicultural activities in this area is not known, but the area appears to be extensively disturbed and burned Douglas Fir stumps and piles of burned slash are the remnants of logging activities. A few fir saplings are currently growing in the area and ground cover includes moss, grass, ferns and duff.

RESULTS

Artifacts were observed and collected at each of the areas surveyed (Map 1). A total of seven bottle fragments, representing two bottles, were found at the proposed sludge application site, and three artifacts, including two cobble choppers and one flaked piece of basalt, were found at three separate locations within the proposed sludge application area. The bottle fragments probably date from 1900-1920, based on amythest tint and machine-made seams. They are most likely associated with early logging activities in the area.

The other three artifacts include two calcareous siltstone cobble choppers and one flaked piece of basalt-like material. The cobble choppers resemble "Olcott" artifacts in material type. They are quite weathered and have attained a patina of light mottled gray as is characteristic of the "Olcott" assemblage. The flaked piece of basalt-like material resembles these artifacts only in material type. Their locations are given below and shown on Map 1.

Location 1: Cobble Chopper, T 32N, R 6E, NE 1/4, SW 1/4, Sec. 19, within northern sludge application area along an existing skid road near T.B.M. #21, .5 kilometers southeast of northwest property gate and 53.6 meters east of Rock Creek.

Location 2: Flaked Basalt, T 32N, R 6E, NE 1/4, SW 1/4, Sec. 19, at extreme south end of northern sludge application site on a point overlooking the Stillaguamish River at the end of an access road, .3 kilometers southeast of Location 1.

Location 3: Cobble Chopper, T 32N, R 6E, NE 1/4, NW 1/4, Sec. 30, within southern sludge application area at the end of an access road which forks off the all-weather road to the south, 13 meters west of the edge of the bluff which overlooks the Stillaguamish River, near T.B.M. #4 and Well #3.

Location 4: Bottle Fragments, T 32N, R 5E, Sec. 24, situated in the organic soil layer at the proposed sludge lagoon site, .3 kilometers north of the crossroads and 10 meters west of the road which borders the powerlines to the west.

RECOMMENDATIONS

In view of the presence of "Olcott-like" artifacts on the proposed sludge application area, it is recommended that further archaeological consideration be given to this particular portion of the project area as these remains represent an as yet little understood phase in the prehistory of the Puget Sound Region.

As it is quite likely that additional remains are present, which could not be located during the recent reconnaissance due to poor ground visibility, we recommend that the project be allowed to proceed with the stipulation that subsequent to completion of access roads and skidder trails in the sludge application areas as shown on Map 1, a professional archaeologist walk these newly exposed areas to locate any potentially significant remains which may be uncovered.

Additionally, if in the course of construction of sludge lagoon facilities, unanticipated cultural remains are encountered, work should be halted in the immediate vicinity and the State Office of Archaeology and Historic Preservation should be contacted immediately.

This report should not be considered to be permission to proceed with the project in question. It contains professional opinions on cultural rewources which might be affected by the project. This report should be submitted to the appropriate review agencies for their comments prior to the commencement of any ground disturbing activities.

REFERENCES CITED

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Appendix F

Water Quality and Groundwater Data

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Table F-1. North Fork of the Stillaguamish River Water Quality Data[1]

parameter	units	# of samples	statistic	4 years data
Specific conductance	umhos	59	mean	62
			maximum	97
ph	units	59	minimum	6.6
			maximum	8.4
temperature	degree C.	59	maximum	17.8
color	platinum cobalt units	56	mean	36
			maximum	
turbidity	NTU	56	mean	10.4
			maximum	120
dissolved oxygen	mg/l	59	minimum	9.8
			mean	11.6
nitrate & nitrite	mg/l as N	59	mean	.25
			maximum	.62
ammonia	mg/l as N	59	mean	.05
			maximum	.48
ammonia	mg/l as NH4	9	mean	.06
total phosphorus	mg/l as P	59	mean	.03
			maximum	.48
total phosphorus	mg/l as PO4	9	mean	.07
dissolved Ortho phosphorus	mg/l as P	59	mean	.003
dissolved Ortho phosphorus	mg/l as PO4	33	mean	.02
hardness	mg/l	25	mean	24.2
non carbonate hardness	mg/l	25	mean	2.8
dissoved calcium	mg/l	25	mean	6.5
dissolved magnesium	mg/l	25	mean	1.9
dissolved sodium	mg/l	25	mean	1.9
dissolved potassium	mg/l	25	mean	.6
bicarbonate	mg/l	26	mean	26.7
carbonate	mg/l	25	mean	0
alkalinity	mg/l as CaCO3	26	mean	21.8
carbon dioxide	mg/l	26	mean	2.3
dissolved sulfate	mg/l	24	mean	4.3
dissolved chloride	mg/l	25	mean	2.0
fecal coliform[2]	no/100ml	4	mean	57
			maximum	120

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[1] Data from USGS Water Resource Date 19771980

[2] Data collected on August 12, 1977

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Table F-2. State of Washington Water Quality Standards

		Fecal Coliform Organisms, MPN/ 100 ml (a)	Dissolved Oxygen, mg/l	Total Dissolved Gas % Saturation	Temperature °C (b)	pH (c)	Turbidity, JTU (d)	Toxic Radioactive, or Deleterious Material Concentration	Aesthetic Values
AA Extraordinary	Fresh-water	50 (10%>100)	>9.5	<110	16 t= 23/(T+5)	6.5-8.5 (0.1)	<5	Shall be less than those which may affect public health, the natural aquatic environment, or the desirability of the water for any usage.	Aesthetic values shall not be impaired by the presence of materials or their effects, excluding those of natural origin, which offend the senses of sight, smell, touch or taste.
	Marine water	14 (10%>43)	>7.0	< 110	13 t= 8/(T-4)	7.0-8.5 (0.1)	<5		
A Excellent	Fresh-water	100 (10%>200)	>8.0	<110	16 t=28/(T+7)	6.5-8.5 (0.25)	<5	Shall be below those of public health significance, or which may cause acute or chronic toxic conditions to the aquatic biota, or which may adversely affect any water.	Aesthetic values shall not be impaired by the presence of materials or their effects, excluding those of natural origin, which offend the senses of sight, smell, touch or taste.
	Marine water	14 (10%>43)	>6.0	<110	18 t= 12(T-2)	7.0-8.5 (0.25)	<5		
B Good	Fresh-water	200 (10%>400)	>6.5 (h)	<110	21 t= 24/(T+9)	6.5-8.5 (0.5)	<10	Shall be below those which adversely affect public health during the exercise of characteristic usages, or which may cause acute or chronic toxic conditions to the aquatic biota, or which may adversely affect characteristic water uses.	Shall not be reduced by dissolved, suspended, floating or submerged matter not attributable to natural causes, so as to affect water usage or taint the flesh of edible species.
	Marine water	100 (10%>200)	>5.0 (h)	<110	19 t= 16/T	7.0-8.5 (0.5)	<10		
C Fair	Fresh-water	200 (10%>400)	>5.0 (e)	<110	24 t= 39/(T+11)	6.5-9.0 (0.5)	<10	Shall be less than those which may affect public health, the natural aquatic environment, or the desirability of the water for any usage.	Aesthetic values shall not be impaired by the presence of materials or their effects, excluding those of natural origin, which offend the senses of sight, smell, touch or taste.
	Marine water		>4.0 (e)	<110	22 t= 20/(T+2)	7.0-9.0 (0.5)	<10		
Lake Class	Freshwater	50 (10%>100)	(g)	<110	(h)	(h)	<5	Shall be less than those which may affect public health, the natural aquatic environment, or the desirability of the water for any usage.	Aesthetic values shall not be impaired by the presence of materials or their effects, excluding those of natural origin, which offend the senses of sight, smell, touch or taste.

(a) Shown in parentheses are the maximum percentages of samples allowed to exceed values indicated, when associated with any fecal source.
(b) Water temperature shall not exceed values shown, due in part to measurable (0.5°F) increases resulting from human activities, nor shall such temperature increases, at any time, exceed the (t) value of the formula shown: t = permissive increase; T = water temperature due to all causes combined.
(c) Shall not be within the range shown, with an induced variation of less than units shown in parentheses.
(d) The natural turbidity conditions shall not be exceeded by more than the value shown.
(e) Dissolved oxygen shall not exceed values shown, or 50 percent saturation, whichever is greater.
(f) No measurable decrease from natural conditions.
(g) No measurable change from natural conditions.
(h) Dissolved oxygen shall not exceed values shown, or 70 percent saturation, whichever is greater.

Table F-3. Stream Water Quality Standards

Parameter	Units	Statistic	Water Quality Standard
Fecal Coliform	No./100 ml.	Median	<100
		10 percentile	<200
Dissolved Oxygen	mg/l	Minimum	8.0
Temperature	°C	Maximum	18
		Increase[a]	0.3
pH		Maximum	8.5
		Minimum	6.5
		Variation[a]	0.5
Turbidity	NTU	Increase[a]	5

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[a] Increase or variation due to human activities

NOTE: < = Less than
Standards from WAC 173-201

SOURCE: Metro 1983d.

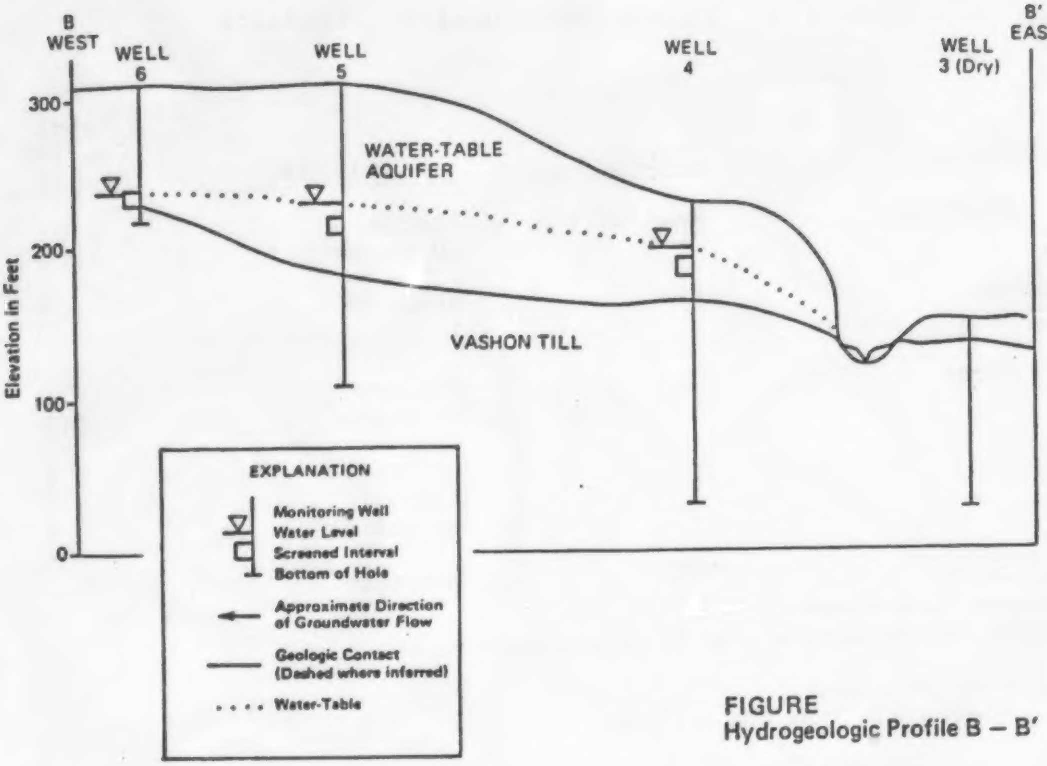
B
WEST
WELL 6
WELL 5
WELL 4
WELL 3 (Dry)
B'
EAST
300
200
100
0
Elevation in Feet
WATER-TABLE AQUIFER
VASHON TILL
EXPLANATION
Monitoring Well
Water Level
Screened Interval
Bottom of Hole
Approximate Direction of Groundwater Flow
Geologic Contact (Dashed where inferred)
Water-Table

FIGURE
Hydrogeologic Profile B — B'

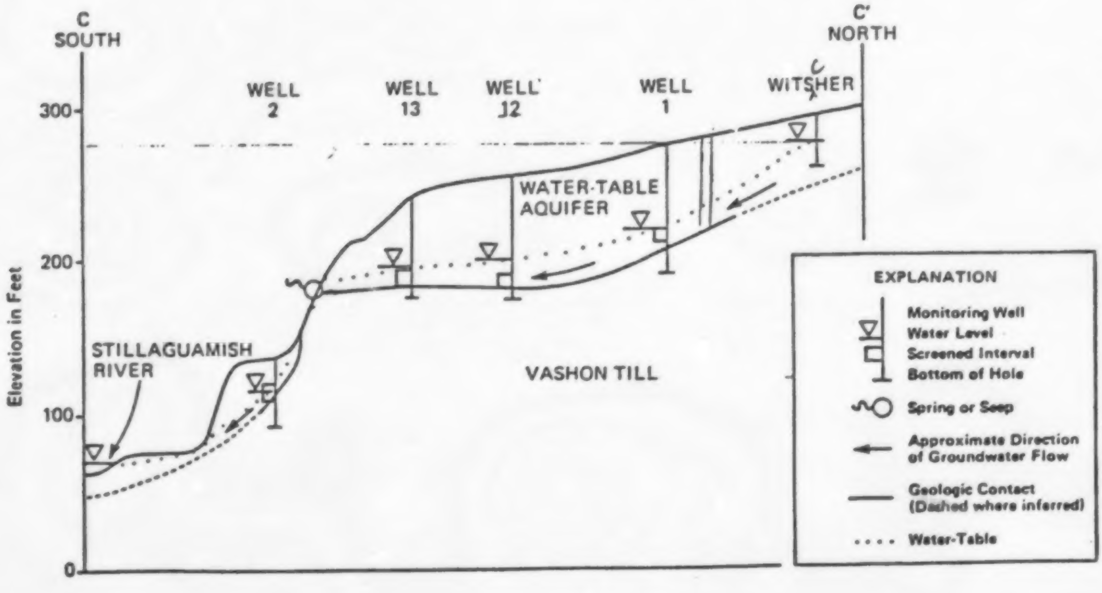
C
SOUTH
C'
NORTH
WELL 2
WELL 13
WELL 12
WELL 1
WITSHER
300
200
100
0
Elevation in Feet
WATER-TABLE AQUIFER
STILLAGUAMISH RIVER
VASHON TILL
EXPLANATION
Monitoring Well
Water Level
Screened Interval
Bottom of Hole
Spring or Seep
Approximate Direction of Groundwater Flow
Geologic Contact (Dashed where inferred)
Water-Table

FIGURE F-1
Hydrogeologic Profile C — C'

SOURCE: Metro 1982a.

Table F-4. Pilchuck Tree Farm Spring Water Analysis
(Sampled March, May, June, July 1982)

	Bluff Springs			
Conventional Parameters	Unit	Mean (n = 7)	Minimum	Maximum
NH_3-N	mg/l	.019	.003	.05
NO_2+NO_3-N	mg/l	1.46	0.33	2.64
Total P	mg/l	.16	.03	.51
Total K	mg/l	1.15	<.77	1.66
pH		7.1	6.7	7.6
Turbidity		3.8	0.6	8.2
Conductivity		96	82	110
Metals				
Cadmium	mg/l	<.0001	<.0001	.00014
Chromium	mg/l	<.024	<.02	.03
Copper	mg/l	<.007	<.001	.02
Mercury	mg/l	<.0002	<.0002	.0005
Nickel	mg/l	.026	.02	.03
Lead	mg/l	<.029	<.02	.04
Zinc	mg/l	<.006	<.006	.013
Bacteria (Geometric Means)				
Total Coliform	MPN/100 ml	113	8	700
Fecal Coliform	MPN/100 ml	4	<2	17
Fecal Streptococci	MPN/100 ml	74	17	490

Viruses - Not analyzed

Parasites - Not detected in 2 samples tested

Chlorinated Organics - Not detected in 2 samples tested

NOTE: Yersinia was isolated from one sample.

MPN = Most Probable Number
< = Less than

SOURCE: Metro 1983d.

Table F-5. Preproject Groundwater Quality Data - Pilchuck Tree Farm

TREE FARM - BASELINE GROUNDWATER SAMPLING
STATION A - FRYREAR'S WELL

		SAMPLE DATE AND SAMPLE NUMBER:				
CONVENTIONAL CHEMICALS	DRINKING WATER STANDARDS (EPA)	9/20/82 #5529 - DUPLICATE		11/29/82 #5592	12/13/82 #5754	1/3/83 #5759
Ammonium-N (mg/l)	---	.0031	.0029	<.001	.011	.0086
Nitrate-N (mg/l)	10.0 mg/l	.42	.42	.43	.087	.44
Phosphorus (mg/l)	---	.0145	.022	.027	.021	.055
Potassium (mg/l)	---	.54	.45	NA	.99	1.1
pH	---	6.5	6.5	6.7	7.8	8
Turbidity (NTU)	---	1.5	1.5	.1	2.1	3.4
Conductivity (Mmhos)	---	50	53	53	60	60
METALS						
Arsenic (mg/l)	0.05 mg/l	<.003	<.003	NA	<.002	<.002
Barium (mg/l)	1.0 mg/l	.17	.15	NA	.06	.12
Cadmium (mg/l)	0.01 mg/l	<.0001	<.0001	NA	.00017	*
Chromium (mg/l)	0.05 mg/l	.0019	.0015	NA	<.001	.0028
Copper (mg/l)	---	.01	.01	NA	.0013	.019
Iron (mg/l)	---	.12	.08	NA	NA	NA
Lead (mg/l)	0.05 mg/l	.0021	.0025	NA	<.001	.0012
Mercury (mg/l)	0.002 mg/l	<.0002	<.0002	NA	.0003	<.0002
Nickel (mg/l)	---	.0014	.02	NA	.0019	.0032
Selenium (mg/l)	0.01 mg/l	<.0002	<.0002	NA	<.001	<.001
Silver (mg/l)	0.05 mg/l	<.0001	<.0001	NA	<.0001	.0001
Zinc (mg/l)	---	.3	.056	NA	.017	*
BACTERIA						
Total coliform (# per 100 ml)	<2 per 100 ml	<2		<2	<2	9
Fecal coliform (# per 100 ml)	<2 per 100 ml	<2		<2	<2	<2
Fecal strept. (# per 100 ml)	---	5		<2	<2	<2
Salmonella (# per 100 ml)	---	<3		NA	NA	<3
Yersinia (# per 100 ml)	---	<3		NA	NA	*
VIRUS - Total (# per 100 gal)	---	<2		NA	NA	<2
PARASITES	---	N.D.		NA	NA	*
ORGANIC TOXICANTS		N.D.		NA	NA	*

N.D. - Not detected
N.A. - Not analyzed

(*data unavailable)

Results of the bacteria testing have been discussed in a previous memo. No chemical measurement exceeded safe drinking water standards. Fluctuations in nutrient content are not unusual and pose no health concerns. Occasional changes in trace element concentrations may also be expected, particularly when the element is present near the limits of detection.

TREE FARM - BASELINE GROUNDWATER SAMPLING
STATION B - WILSONS' WELL

		SAMPLE DATE AND SAMPLE NUMBER:				
CONVENTIONAL CHEMICALS	DRINKING WATER STANDARDS (EPA)	9/20/82 #5530	9/27/82 #5544	11/29/82 #5593	12/13/82 #5755	1/3/83 #5760
Ammonium-N (mg/l)	---	.0039		<.001	<.001	.012
Nitrate-N (mg/l)	10.0 mg/l	1.8		3.2	3.53	3.61
Phosphorus (mg/l)	---	.42		.031	.029	.026
Potassium (mg/l)	---	1.05		NA	1.35	1.52
pH	---	6.2		6.6	5.7	7.5
Turbidity (NTU)	---	2.4		.06	1.2	1.5
Conductivity (Mmhos)	---	148		137	145	133
METALS						
Arsenic (mg/l)	0.05 mg/l	<.003		NA	<.002	<.002
Barium (mg/l)	1.0 mg/l	.18		NA	.06	.15
Cadmium (mg/l)	0.01 mg/l	<.0001		NA	.00031	*
Chromium (mg/l)	0.05 mg/l	.0035		NA	<.001	.0034
Copper (mg/l)	---	.02		NA	.0074	.013
Iron (mg/l)	---	.5		NA	NA	NA
Lead (mg/l)	0.05 mg/l	.0055		NA	<.001	.0011
Mercury (mg/l)	0.002 mg/l	<.0002		NA	.0002	.0003
Nickel (mg/l)	---	.02		NA	.0016	.0014
Selenium (mg/l)	0.01 mg/l	<.00017		NA	<.001	<.001
Silver (mg/l)	0.05 mg/l	.0002		NA	<.0001	<.0001
Zinc (mg/l)	---	<.006		NA	.021	*
BACTERIA						
Total coliform (# per 100 ml)	<2 per 100 ml	79	33	4	110	5
Fecal coliform (# per 100 ml)	<2 per 100 ml	<2	<2	<2	<2	<2
Fecal strept. (# per 100 ml)	---	240		8	49	2
Salmonella (# per 100 ml)	---	<3		NA	NA	<3
Yersinia (# per 100 ml)	---	<3			NA	*
VIRUS - Total (# per 100 gal)	---	<2		NA	NA	<2
PARASITES	---	N.D.		NA	NA	*
ORGANIC TOXICANTS		N.D.		NA	NA	*

N.D. - Not detected
N.A. - Not analyzed

(*data unavailable)

Results of the bacteria testing have been discussed in a previous memo. No chemical measurement exceeded safe drinking water standards. Fluctuations in nutrient content are not unusual and pose no health concerns. Occasional changes in trace element concentrations may also be expected, particularly when the element is present near the limits of detection.

Table F-5. Cont'd.

TREE FARM - BASELINE GROUNDWATER SAMPLING
STATION C - WITSCHER'S WELL

CONVENTIONAL CHEMICALS	DRINKING WATER STANDARDS (EPA)	SAMPLE DATE AND SAMPLE NUMBER: 9/20/82 #5531	9/27/82 #5545 (Coliform only)	11/29/82 #5594	12/13/82 #5594	1/3/83 #5761
Ammonium-N (mg/l)	---	.0038		<.001	.002	.002
Nitrate-N (mg/l)	10.0 mg/l	1.96		4.09	6.3	4.17
Phosphorus (mg/l)	---	.0057		.0097	.01	.017
Potassium (mg/l)	---	.37		NA	.82	.88
pH	---	6.2		5.9	6	7.7
Turbidity (NTU)	---	5.7		.05	.45	1
Conductivity (Mmhos)	---	194		89	120	100
METALS						
Arsenic (mg/l)	0.05 mg/l	<.003		NA	<.002	<.002
Barium (mg/l)	1.0 mg/l	.21		NA	.12	.1
Cadmium (mg/l)	0.01 mg/l	<.0001		NA	<.0001	*
Chromium (mg/l)	0.05 mg/l	<.001		NA	<.001	.002
Copper (mg/l)	---	.05		NA	.073	.22
Iron (mg/l)	---	<.03		NA	NA	NA
Lead (mg/l)	0.05 mg/l	.024		NA	.0017	.0015
Mercury (mg/l)	0.002 mg/l	<.0002		NA	<.0002	.0002
Nickel (mg/l)	---	.02		NA	.0027	.0049
Selenium (mg/l)	0.01 mg/l	.0004		NA	<.001	<.001
Silver (mg/l)	0.05 mg/l	<.0001		NA	<.0001	<.0001
Zinc (mg/l)	---	.054		NA	.015	*
BACTERIA						
Total coliform (# per 100 ml)	<2 per 100 ml	28	17	22	13	2
Fecal coliform (# per 100 ml)	<2 per 100 ml	<2	<2	<2	<2	<2
Fecal strept. (# per 100 ml)	---	11		<2	<2	<2
Salmonella (# per 100 ml)	---	<3		NA	NA	<3
Yersinia (# per 100 ml)	---	<3		NA	NA	*
VIRUS - Total (# per 100 gal)	---	<2		NA	NA	<2
PARASITES	---	N.D.		NA	NA	*
ORGANIC TOXICANTS		N.D.		NA	NA	*

N.D. - Not detected
N.A. - Not analyzed

(*data unavailable)

Results of the bacteria tesing have been discussed in a previous memo. No chemical measurement exceeded safe drinking water standards. Fluctuations in nutrient content are not unusual and pose no health concerns. Occasional changes in trace element concentrations may also be expected, particularly when the element is present near the limits of detection.

TREE FARM - BASELINE GROUNDWATER SAMPLING
STATION D - LINDAL/ESPERSON WELL

CONVENTIONAL CHEMICALS	DRINKING WATER STANDARDS (EPA)	SAMPLE DATE AND SAMPLE NUMBER: 9/20/82 #5532	11/19/82 #5595	12/13/82 #5757	1/3/83 #5762
Ammonium-N (mg/l)	---	.0031	<.001	<.001	.0069
Nitrate-N (mg/l)	10.0 mg/l	1.78	4.51	3.72	4.42
Phosphorus (mg/l)	---	.0021	.0097	.013	.0066
Potassium (mg/l)	---	.3	NA	.75	.86
pH	---	6.8	5.9	6.8	7.5
Turbidity (NTU)	---	4.5	.25	.47	.6
Conductivity (Mmhos)	---	60	55	69	65
METALS					
Arsenic (mg/l)	0.05 mg/l	<.003	NA	<.002	<.002
Barium (mg/l)	1.0 mg/l	.07	NA	.07	.08
Cadmium (mg/l)	0.01 mg/l	<.0001	NA	.00023	*
Chromium (mg/l)	0.05 mg/l	<.001	NA	<.001	.0023
Copper (mg/l)	---	.0057	NA	.0053	.024
Iron (mg/l)	---	<.03	NA	NA	NA
Lead (mg/l)	0.05 mg/l	.0026	NA	.056	.0019
Mercury (mg/l)	0.002 mg/l	<.0002	NA	<.0002	<.0002
Nickel (mg/l)	---	.0012	NA	<.001	.016
Selenium (mg/l)	0.01 mg/l	<.00017	NA	<.001	<.001
Silver (mg/l)	0.05 mg/l	<.0001	NA	<.0001	.0002
Zinc (mg/l)	---	.036	NA	.043	*
BACTERIA					
Total coliform (# per 100 ml)	<2 per 100 ml	<2	14	70	11
Fecal coliform (# per 100 ml)	<2 per 100 ml	<2	<2	<2	<2
Fecal strept. (# per 100 ml)	---	<2	<2	<2	<2
Salmonella (# per 100 ml)	---	<3	NA	NA	<3
Yersinia (# per 100 ml)	---	<3	NA	NA	*
VIRUS - Total (# per 100 gal)	---	<2	NA	NA	<2
PARASITES	---	N.D.	NA	NA	*
ORGANIC TOXICANTS		N.D.	NA	NA	*

N.D. - Not detected
N.A. - Not analyzed

(*data unavailable)

Results of the bacteria testing have been discussed in a previous memo. No chemic measurement exceeded safe drinking water standards. Fluctuations in nutrient con are not unusual and pose no health concerns. Occasional changes in trace element concentrations may also be expected, particularly when the element is present nea the limits of detection.

SOURCE: Metro unpublished data.

Table F-6. Minimum Acceptable Water Supply Quality[a]

Parameter	Statistic	Limit
Total Coliform	Monthly mean	<2/100 ml
	Maximum	4/100 ml
Arsenic	Maximum	0.05 mg/l
Barium	Maximum	1.0 mg/l
Cadmium	Maximum	0.01 mg/l
Chromium	Maximum	0.05 mg/l
Lead	Maximum	0.05 mg/l
Mercury	Maximum	0.002 mg/l
Nitrate (as N)	b	10.0 mg/l[b]
Selenium	Maximum	0.01 mg/l
Silver	Maximum	0.05 mg/l
Endrin	Maximum	0.0002 mg/l
Lindane	Maximum	0.004 mg/l
Methoxychlor	Maximum	0.1 mg/l
Toxaphene	Maximum	0.005 mg/l
2,4 - D	Maximum	0.1 mg/l
2,4,5 - TP (Silvex)	Maximum	0.01 mg/l

---

[a] Values are Primary Drinking Water Standards as defined by the Environmental Protection Agency.

[b] The 12-month moving geometric mean shall not exceed 5 mg/l and the maximum monthly average for November, December, and January shall not exceed 10 mg/l.

SOURCE: Metro 1983d.

Appendix G

EPA Criteria for Classification of Solid Waste Disposal Facilities and Practices (40 CFR Part 257)

federal register

Thursday
September 13, 1979

Part IX

Environmental Protection Agency

Criteria for Classification of Solid Waste Disposal Facilities and Practices; Final, Interim Final, and Proposed Regulations (as corrected in the Federal Register of September 21, 1979)

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ENVIRONMENTAL PROTECTION AGENCY

40 CFR Part 257

[Docket No. 4004; FRL 1234-1]

Criteria for Classification of Solid Waste Disposal Facilities and Practices

AGENCY: Environmental Protection Agency.

ACTION: Final rule and interim rule.

SUMMARY: This regulation contains minimum criteria for determining what solid waste disposal facilities and practices pose a reasonable probability of adverse effects on health or the environment. Those facilities that violate the criteria are "open dumps" for purposes of the State Solid Waste Management planning effort supported by EPA under Subtitle D of the Resource Conservation and Recovery Act (RCRA or the Act). The criteria also provide the standard to be applied by the Federal district courts in determining whether parties have engaged in acts that violate the prohibition of open dumping, also contained in Subtitle D of RCRA. The criteria also partially fulfill the requirement of Section 405 of the Clean Water Act (CWA) to provide guidelines for the disposal and utilization of wastewater treatment plant sludge. Any owner or operator of a publicly owned treatment works must comply with these criteria when disposing of sludge on the land.

EFFECTIVE DATE: October 15, 1979.

DATE: For purposes of the Interim Final portions of the criteria [sections 257.3-5 and 257.3-6(b)], public comments will be accepted until November 20, 1979.

ADDRESS: Submit comments to: Mr. Emery Lazar, Docket 4004.1, Office of Solid Waste (WH-564), EPA, Washington, D.C. 20460.

FOR FURTHER INFORMATION CONTACT: Mr. Truett V. DeGeare, Jr., P.E., Office of Solid Waste (WH-563), U.S. Environmental Protection Agency, 401 M Street, S.W., Washington, D.C. 20460, Telephone (202) 755-9120.

SUPPLEMENTARY INFORMATION:

I. Authority

This regulation is issued under authority of Sections 1008(a)(3) and 4004(a) of the Solid Waste Disposal Act, as amended by the Resource Conservation and Recovery Act of 1976, 42 U.S.C. 6907(a)(3) and 6944(a), as well as Section 405(d) of the Clean Water Act, as amended, 42 U.S.C. 345.

II. Background

This regulation was published in the Federal Register in proposed form for public review and comment on February 6, 1978. The Agency held five public hearings and eleven public meetings to discuss the proposed regulation and received a substantial number of written comments on the proposal. Having considered the views of the public, the Agency is now promulgating this regulation in final form. This preamble discusses some of the more significant issues raised during the public comment period and revisions made on the basis of those comments.

The objectives of the Act are to promote the protection of health and the environment and to conserve valuable material and energy resources. In order to accomplish this, the Act sets forth a national program to improve solid waste management, including control of hazardous wastes, resource conservation, resource recovery, and establishment of environmentally sound solid waste disposal practices. This is to be carried out through a cooperative effort among Federal, State, and substate governments and private enterprise.

Subtitle D of the Act fosters this cooperative effort by providing for the development of State and regional solid waste management plans that involve all three levels of government. As the Federal partner in this process, EPA seeks, through regulations and financial assistance, to aid State initiatives in the formulation and implementation of such plans.

Section 4002(b) of the Act requires the Administrator to promulgate Guidelines for the Development and Implementation of State Solid Waste Management Plans. On July 31, 1979, EPA issued those guidelines (44 FR 45066). While those guidelines are to consider a broad range of topics, Section 4003 of the Act identifies the minimum requirements which State plans must address. EPA provides financial assistance to help the States develop and implement their plans. Under Section 4007, EPA reviews and approves State plans which satisfy the minimum requirements of Section 4003.

The State solid waste management plan is the centerpiece of the Subtitle D program. Through the plan the State identifies a general strategy for protecting public health and the environment from adverse effects associated with solid waste disposal, for encouraging resource recovery and resource conservation, for providing adequate disposal capacity in the State, and for dealing with other issues relevant to solid waste management. The plan must also set forth the institutional arrangements that the State will use to implement this strategy. (A more detailed description of the planning program is contained in the Preamble accompanying the Section 4002(b) guidelines.)

A. Section 4004: Disposal Facility Criteria

Under section 4004(a) of the Act the Administrator is to promulgate "regulations containing criteria for determining which facilities shall be classified as sanitary landfills and which shall be classified as open dumps * * *" The criteria establish the level of protection necessary to provide that "no reasonable probability of adverse effects on health or the environment" will result from operation of the facility. In setting these criteria EPA is providing a general definition of "sanitary landfill" and "open dump". As part of their planning programs, the States will evaluate existing disposal facilities to determine whether they comply with the Section 4004 criteria. Those facilities which do not satisfy the criteria are "open dumps" under the Act. EPA will, under authority of Section 4005(b), publish a list of open dumps in the Federal Register.

The inventory of "open dumps" will serve two major functions. First, it will inform the Congress and the public about the extent of the problem presented by disposal facilities which do not adequately protect public health and the environment. Second, it will provide an agenda for action by identifying a set of problem facilities, routinely used for disposal, which should be addressed by State solid waste management plans in accordance with Section 4003 of the Act.

Essentially, the inventory is a planning tool which supports the State planning effort. The States must know where the problem facilities are in order to satisfy Section 4003(3) which requires that the plan "provide for the closing or upgrading of all existing open dumps within the States * * *."

B. Section 1008(a)(3): Open Dumping Criteria

Under Section 1008(a)(3) of the Act the Administrator is to publish suggested guidelines that provide minimum criteria "to define those solid waste management practices which constitute the open dumping of solid waste or hazardous waste." Thus, these criteria are to establish a broad definition of the act of open dumping, which is prohibited under Section 4005(c) of the Act.

The prohibition may be enforced in Federal district court through the citizen suit provision in Section 7002. The Act does not give EPA authority to take legal action against parties that may violate the open dumping prohibition. The application of the open dumping criteria to the specific acts of specific individuals is a matter for the Federal courts to determine in the context of particular cases. Judicial review of specific acts in the context of open dumping suits should not be confused with State planning activities, particularly the evaluation of disposal facilities for the inventory of open dumps. The inclusion of a facility in the list of open dumps is not an administrative determination by EPA that any particular parties are engaging in prohibited acts of open dumping. (The Preamble accompanying the Guidelines for Development and Implementation of State Solid Waste Management Plans (44 FR 45066) provides a more detailed explanation of this issue.)

C. Section 405(d): Sludge Disposal Guidelines

Under Section 405(d) of the Clean Water Act EPA issues guidelines for the disposal and utilization of sludge. Under Section 405(e) of the CWA owners and operators of publicly owned treatment works (POTW's) must dispose of sludges from such works in accordance with those guidelines. Criteria designed to avoid a reasonable probability of adverse effects on health or the environment from disposal of sludge on land are clearly within the scope of this provision of the CWA.

D. Copromulgation of the Criteria

The criteria which EPA promulgates today are designed to fulfill or partially fulfill the requirements of each of the provisions discussed above. While all three provisions embody different implementation schemes, they all are concerned with the adverse effects on health or the environment that may be caused by solid waste disposal activities. Since there is an inherent compatibility of purpose among the three provisions, EPA has decided to structure the criteria so they may be used in all three contexts. EPA believes that co-promulgation of regulations, where possible, improves the quality of its regulatory efforts by eliminating the potential for inconsistencies among similar regulations and by providing a clear statement to the regulated community of the standards to which they will be held.

As an example of the compatibility between provisions, the facility classification criteria for purposes of the State planning program can, and probably should, be concerned with the same set of environmental effects as the criteria defining the prohibited act of open dumping. Regardless of whether one is evaluating facilities to aid in the establishment of setting state planning priorities or examining the acts of specific individuals to determine legal liability for open dumping, the same set of environmental effects should be of concern. At the same time, having a single set of criteria for defining unacceptable environmental effects does not undermine the use of that definition for different purposes.

It should be pointed out that these criteria are not necessarily the only guidelines to be promulgated under Section 405(d) of the CWA. These criteria apply where the owners and operators of POTW engage in the placement of sludge on the land. Future EPA guidelines on sludge disposal and utilization may address incineration, energy recovery, and give-away or sale of processed sludge.

III. General Approach

This regulation sets forth eight criteria that address broad classes of health and environmental effects that may be caused by solid waste disposal activities. The criteria are structured to define unacceptable impacts, those that present a "reasonable probability of adverse effects on health or the environment." In terms of the three statutory provisions authorizing this regulation, the criteria define an open dump (RCRA Section 4004), the minimum elements of prohibited open dumping practices (RCRA Section 1008(a)(3)) and the effects which must be avoided by POTW owners and operators (CWA Section 405).

EPA recognizes that these criteria will be applied to a variety of situations and that there is a need for flexibility in the standards to allow them to be applied to particular circumstances. During the comment period some reviewers expressed preference for greater specificity in the criteria, including more detailed design and operating requirements. Others favored greater flexibility and opportunity for consideration of local, site-specific conditions.

In developing the final criteria the Agency attempted to be as specific as possible without reducing the opportunity for State and local solid waste management and enforcement agencies to take into account the site-by-site variations and make assessments based on local conditions. Wherever possible EPA tried to set specific performance standards that define unacceptable environmental effects. Such an approach should provide a concise and measurable means of determining compliance with the criteria. However, in some situations it was not possible to devise a meaningful performance standard for the environmental effect of concern, given the lack of experience with such an approach to regulation of solid waste.

Where specific performance standards were not possible, EPA specified an operational technique to achieve the desired level of protection. When that approach was necessary the criteria maintain regulatory flexibility by allowing for the use of alternative techniques that achieve the same general performance level. Parties claiming that alternative approaches provide protection equivalent to that of methods described in the criteria have the burden of establishing that fact.

In addition EPA wishes to emphasize that the standards established in the criteria constitute minimum requirements. These criteria do not pre-empt other State and Federal requirements. Nothing in the Act or the CWA precludes the imposition of additional obligations under authority of other laws on parties engaged in solid waste disposal.

Various commenters criticized EPA's general approach as being either too restrictive or too lenient. Some argued that implementation of the criteria would substantially reduce needed disposal capacity. The Agency recognizes that one of the most critical problems in the solid waste management field today is the lack of acceptable disposal facilities due, in part, to public opposition to their siting. However, this particular rulemaking cannot deal directly with this problem.

The Agency is committed to evaluating other means by which it can help with the problem. Adequate disposal capacity is essential nationwide. Hopefully, implementation of the criteria will increase the credibility of disposal operations, thereby aiding in reducing public opposition to acceptable and needed facilities.

Some commenters felt that the criteria should be written very stringently in order to provide an incentive for initiation of resource recovery and conservation practices. Other commenters observed that, even with increased levels of resource recovery and conservation, disposal facilities would continue to be required into the foreseeable future; even resource recovery facilities produce a residue which requires disposal. The Agency believes that resource recovery and conservation are desirable solid waste management approaches which should be actively pursued. However, the purpose of the criteria is to define disposal activities which pose no reasonable probability of adverse effects on health or the environment, and the criteria have been developed with that goal in mind. While the implementation of these criteria may make resource conservation and recovery more economically competitive, these regulations have not been formulated simply to advance that cause. Such an approach is not authorized by the Act.

EPA also received comments attacking the Agency's use of standards, definitions and approaches developed under other Federal environmental and public health programs. They claimed that incorporating these items into the criteria extends those other programs beyond their statutory authority. While the use of particular Federal standards will be discussed later in this Preamble in the context of each criterion, a general point should be made about the use of approaches developed or employed in other programs. The Act requires that the criteria address adverse health and environmental effects of solid waste disposal, whatever those might be. The use of other Federal Standards in responding to this broad mandate is, in fact, quite desirable in order to minimize duplicative, overlapping and conflicting policies and programs. Unless it can be shown that other Federal standards and approaches are clearly inconsistent with the Act's objectives, it is within the Agency's discretion to use them, where applicable, in writing RCRA regulations.

IV. The Criteria

A. Scope

These criteria apply to the full range of facilities and practices for "disposal" of "solid waste", as those terms are defined in Section 1004 of the Act. Various commenters suggested the exclusion or inclusion of specific types of solid waste disposal activities. EPA examined these suggestions in light of the Act's definitions, Section 1006 of the Act (which directs the Agency to avoid duplicative regulatory programs), the Act's legislative history and the objectives of Subtitle D. EPA has concluded that the criteria apply to all solid waste disposal with the following exceptions:

1. The criteria do not apply to agricultural wastes, including manures and crop residues, returned to the soil as fertilizers or soil conditioners. All other disposal of agricultural wastes, including placement in a landfill or surface impoundment, is subject to these criteria. This exclusion is based on the House Report (H.R. Rep. No. 94–1491, 94th Cong., 2nd Sess. 2(1976)) which explicitly indicates that agricultural wastes returned to the soil are not to be subject to the Act.

2. The criteria do not, at this time, apply to overburden from mining operations intended for return to the mine site. The House Report indicates that this type of overburden is not to be the immediate focus of the Act's programs.

3. The criteria do not apply to domestic sewage or treated domestic sewage. However, the criteria do apply to disposal of sludge resulting from the treatment of domestic sewage. In defining "solid waste" the Act specifically excludes solid or dissolved material in domestic sewage. Treated domestic sewage from which pollutants have been removed in a wastewater treatment plant is still considered to be domestic sewage for purposes of the Act. Including such wastewater effluents within the Act's scope is particularly unnecessary because existing EPA programs concerning treatment of domestic sewage are seeking to assure that these effluents are disposed of in an environmentally sound manner.

However, during the treatment of domestic sewage, solid and dissolved materials are removed from the sewage and collected as sludges. Typically, these sludges are disposed of separately from the treated sewage which passes through the treatment plant. The language of Sections 1004(27) and 1004(26A) indicate that sludge generated by a wastewater treatment plant, water supply treatment plant or air pollution control facility is solid waste for purposes of the Act. EPA believes that while the Congress intended to exempt treated sewage effluents from the Act's provisions, it intended to include sludges created by the operation of treatment facilities. This approach is consistent with Congressional intent, expressed in Section 1002(b)(3) and the legislative history, that the Act specifically address the new solid waste management problem that resulted from effective implementation of programs designed to protect the air, water and other environmental resources.

With this interpretation a question is raised about the operation of septic tanks, a particular type of sewage treatment device. The materials which pass through the tank and are released into drainage fields are analogous to the treated sewage effluent passing through a treatment plant, and thus are not considered solid waste. The materials which settle to the bottom of the septic tank and are subsequently removed for disposal at some other facility are analogous to the sludge created by the operation of other sewage treatment processes. Therefore, septic tank pumpings fall within the Act's definition of solid waste.

4. The criteria do not apply to solid or dissolved materials in irrigation return flows. This exemption is clearly stated in Section 1004(27) of the Act.

5. The criteria do not apply to source, special nuclear, or byproduct material as defined by the Atomic Energy Act of 1954, as amended (68 Stat. 923). This exemption is stated in Section 1004(27) of the Act.

6. The criteria do not apply to industrial discharges which are point sources subject to permits under Section 402 of the Clean Water Act as amended. In defining solid waste the Act specifically exempts these discharges. The principal purpose of this provision is to assure that waters of the United States (the jurisdictional concern of the Clean Water Act) are not regulated under this Act.

7. The criteria do not apply to facilities for the disposal of hazardous wastes subject to Subtitle C of the Act. Section 3004 establishes the standards which will be applicable to such facilities. EPA's final regulations for its hazardous waste program will delineate the class of facilities subject to the Subtitle C requirements.

8. The criteria do not apply to disposal of solid waste by underground well injection that is subject to regulations (40 CFR Part 146) for the Underground Injection Control Program (UICP) under the Safe Drinking Water Act, as amended, 42 U.S.C. 3001, *et seq.* While the subsurface emplacement of fluids through a well (the activity regulated by UICP) could also fall within the Act's broad definition of disposal, Section 1006 of the Act requires that EPA avoid duplication with its other programs (including those under the Safe Drinking Water Act) in administering the Act. Leaving regulation of underground well injection to the UICP is consistent with that mandate and is especially appropriate since the UICP seeks to achieve objectives similar to those of the Act.

B. Definitions (Section 257.2)

General definitions which apply to all the criteria are presented in § 257.2. The section defines "disposal," "facility," "leachate," "open dump," "practice," "sanitary landfill," "sludge," "solid waste," and "state." Also definitions that are only applicable to a particular criteria are presented in that criteria section.

EPA received many comments that reflected a concern over the definition of "facility". Several commenters suggested that EPA exempt such things as wastewater treatment lagoons, potable water treatment lagoons, surface impoundments (pits, ponds, lagoons, basins), mining waste disposal facilities, utility waste disposal facilities and agricultural waste disposal facilities. The Act does not define the term "facility". EPA believes that the term should be interpreted broadly unless such an interpretation clearly conflicts with other provisions or objectives of the Act.

After examining these requests for exemptions in light of the Act and its legislative history, EPA concluded that there was no statutory basis for excluding these types of facilities. All such facilities could present a reasonable probability of adverse effects on health or the environment. EPA does not have any basis for determining that such facilities are not "solid waste disposal facilities" for purposes of the Act.

Several commenters asked whether the definition of "facility" would encompass "backyard" disposal practices such as home compost piles or burning of household wastes. EPA does not believe that Congress intended the Subtitle D classification scheme to be implemented at the household level. Section 1004(27) refers to wastes from "community activities". In addition, the legislative history indicates at several points that "municipal" wastes are of concern under Subtitle D. The Act's emphasis on "community" or "municipal" waste, indicates that the Congress intended to focus on solid waste managment at that level rather than at the household level. EPA believes that "backyard" practices should be controlled through State or local nuisance and public health laws.

Some commenters suggested that disposal facilities used by small communities (especially small facilities in rural areas) be excluded from coverage due to the anticipated higher unit cost (cost per capita or cost per ton of waste) of compliance for such facilities. The Agency found no basis for such an exclusion. In fact, such an exclusion could foster the development of additional small facilities in order to escape the cost of compliance and, cumulatively, could result in greater environmental damage in rural areas. Thus, the criteria apply to large and small facilities, whether urban or rural, because it is essential that all facilities prevent adverse impacts on health and the environment in accordance with the criteria.

Less sophisticated and less costly design and operational techniques, however, may be applicable at smaller facilities due to the smaller quantities of waste disposed and reduced magnitude of potential adverse effects. In addition, small or rural communities may take various approaches to reduce the per capita cost burden and achieve economy of scale through regionalized collection and disposal systems, sharing of equipment among facilities, or operation of facilities only during limited hours.

During the public comment period it was suggested that there be less stringent criteria for existing facilities than for new facilities. In considering this suggestion the Agency has found no difference in the potential adverse effects from existing as opposed to new, facilities. With regard to implementation of the criteria, however, the Act does recognize the need to continue the controlled use of existing facilities while alternatives which comply with the criteria are being developed. In taking steps to close or upgrade existing open dumps, a State may issue compliance schedules that allow use of a disposal facility while it is being upgraded or while alternative disposal options are being developed.

A few commenters also raised the question of whether a junk yard, which may buy or sell waste items, is a solid waste disposal facility. While a junk yard is clearly a "solid waste management" facility under the Act, there is some question whether the operation of a junk yard constitutes the disposal of solid waste.

Under Section 1004(3) "disposal" involves the placement of solid waste into or on any land or water so that a constituent of the waste may enter the environment. This entry of waste materials into the environment is an essential component of the Act's definition. As the Senate Report states, "Disposal is letting wastes out of control" (Sen. Rept. No. 94–988, 94th Cong., 2d Sess. 26 (1976)).

If a junk yard is operated in such a way that no waste material enters the environment then it is possible that it is not a solid waste disposal facility. If constituents of the waste, however, are entering the environment (e.g. battery acids from automobiles leaching into the ground), then the junk yard would be a disposal facility. It is up to the State to determine whether particular junk yard operations constitute disposal of solid waste.

C. Reorganization of the Criteria

After reviewing the comments EPA has decided to change the format of two portions of the criteria as they appeared in the proposed regulation. The criteria concerning environmentally sensitive areas and disease have been reorganized.

The proposed regulation had one section that addressed the location of disposal facilities in wetlands, floodplains, permafrost areas, critical habitats of endangered species, and recharge zones of sole source aquifers, all of which were categorized as "environmentally sensitive areas". In the Preamble to the proposed regulation the Agency also requested comment on other areas, specifically karst terrain and active fault zones, for similar consideration.

Environmentally sensitive areas are no longer addressed in a separate section. Criteria regarding floodplains and critical habitats of endangered species appear in independent sections discussed later. Wetlands are addressed in the section on surface water, since wetlands are treated in the same manner as surface waters under the Clean Water Act. Concerns for recharge zones of sole source aquifers are directly related to those for ground-water protection; thus, protection of sole source aquifers has been incorporated into the ground-water section of the criteria.

Permafrost areas are no longer addressed in the criteria. While EPA is concerned with the effects of solid waste disposal in permafrost areas there are several reasons why it is not appropriate to establish a national criterion concerning permafrost. Permafrost areas only occur in Alaska in the United States. The State of Alaska has authority to regulate solid waste disposal and to protect permafrost. EPA believes that the State's program is adequate to protect these areas. Under Section 6001 of the Act Federal facilities must comply with applicable State solid waste disposal requirements. Thus, there should be full compliance with those State disposal requirements affecting permafrost areas. Moreover, the criteria addressing floodplains, surface water and ground water will cover many of the environmental effects of concern in such areas. Under these circumstances it does not seem necessary to establish separate permafrost criteria at this time.

In response to the Agency's request, some commenters described risks inherent in disposal of solid waste in karst terrain and active fault zones. The concerns raised pertained primarily to ground water. The Agency believes that these concerns are adequately addressed by the ground-water criteria and has not provided a separate criteria for karst terrain or active fault zones.

In the proposed regulation the criterion for disease just addressed the problem presented by disease-carrying vectors. In the section addressing food-chain crops, the proposed criteria provided for controls to reduce the likelihood for transmission of pathogens from the solid waste to humans. Since both provisions concerned the prevention of disease, they have been combined in § 257.3–6.

D. Floodplains (Section 257.3–1)

Disposal of solid waste in floodplains may have several significant adverse impacts: (1) If not adequately protected, wastes may be carried by flood waters and flow from the site, affecting downstream water quality and structures; (2) filling in the floodplain may restrict the flow of flood waters, causing greater flooding upstream; and (3) filling in the floodplain may reduce the size and effectiveness of the flood-flow retaining capacity of the floodplain, which may cause a more rapid movement of flood waters downstream, resulting in higher flood levels and greater flood damages downstream. For these reasons it is generally desirable to locate disposal facilities outside of floodplains.

The proposed criteria required that a facility not restrict the flow of the base flood nor reduce the temporary water-storage capacity of the floodplain, in order to prevent increased flooding upstream or downstream resulting from the base flood. In addition, the proposal required that the facility be protected against inundation by the base flood, unless the facility is for land application of solid waste for beneficial utilization as agricultural soil conditioners or fertilizers.

In developing this criterion EPA sought to comply with Executive Order 11988, "Floodplain Management" (42 FR 28951), which requires Federal agencies, in carrying out their responsibilities, to take actions to reduce the risk of flood loss, to minimize the impact of floods on human safety, health and welfare, and to restore and preserve the natural and beneficial values served by floodplains. In accordance with Executive Order 11988, EPA consulted with the Water Resources Council and the Federal Insurance Administration of the Department of Housing and Urban Development. Both of these agencies deal with floodplain management issues.

A few commenters questioned whether floodplain concerns were within the statutory scope of these regulations. Clearly, improper disposal of solid waste in a floodplain can have adverse effects on health and the environment. EPA is not aware of any other Federal program that addresses the particular environmental threat presented by solid waste disposal activities in floodplains. Therefore, there is no question that these concerns are within the purview of this regulation.

After evaluating the proposed floodplains criterion in light of the comments, EPA re-evaluated the rationale for the proposed regulation. There was an apparent contradiction in the criterion between the requirement to prevent any increased flooding and the provision to protect against inundation. As several commenters pointed out, compliance with one was likely to lead to violation of the other. In addition EPA concluded that it was not necessary to eliminate any and all marginal increases, however small, in flood levels caused by disposal operations. Moreover, not all inundation of disposal facilities leads to adverse environmental effects. Depending on the waste material there may be no adverse downstream effects; where such effects could occur, proper control measures to prevent washout of the waste materials (e.g. diking) would be sufficient to avoid the problem.

Therefore, EPA made the following changes in the floodplain criterion:

1. The disposal facility or practice should seek to avoid washout of solid waste, rather than necessarily prevent inundation of the waste. This change allows for the development of management practices or facility designs that can avoid washout of the solid waste without preventing all inundation by flood waters. (Several commenters indicated that such approaches were feasible.)

2. All of the requirements are linked to an assessment of the hazard to human life, wildlife, land or water. This is designed to avoid a situation where any increase in flood levels attributable to disposal activities or washout of waste is automatically precluded. EPA does not believe that the incremental effect of solid waste operations on floodplain management justifies such a drastic approach. In some cases, however, disposal activities may present a significant marginal increase in the risk of flood damage. It is appropriate to avoid such a risk. EPA cannot specify for all situations what that unacceptable risk will be. This issue must be resolved on a case-by-case basis in the implementation of these criteria.

3. The exception for land application of solid waste for beneficial utilization as an agricultural soil conditioner or fertilizer has been eliminated. EPA believes that special exceptions for classes of activities are no longer necessary. In more clearly specifying the performance objective for disposal in floodplains, the criteria provide the flexibility to allow continuation of those activities that do not present health and environmental hazards.

Some commenters questioned the use of the 100-year base flood in defining the floodplain of concern. EPA believes that this is an appropriate definition. The 100-year floodplain does not represent a flood that will occur only once in 100 years. It is the flood which has a one percent or greater chance of occurring in any one year. Such a flood may occur several times or never occur within a given 100-year period. In selecting the 100-year flood to define the floodplain of concern EPA is maintaining consistency with the approach in other Federal programs and in Executive Order 11988.

Some commenters misinterpreted the criteria as a prohibition against locating facilities in floodplains. While areas other than floodplains are often preferable locations for disposal facilities, the proposed criteria did not provide such a prohibition. Certainly, that point is even clearer in the floodplain criterion issued today.

E. Endangered and Threatened Species (Section 257.3–2)

Solid waste disposal activities can adversely affect endangered and threatened wildlife by releasing toxic materials into the environment and by disrupting the ecosystems on which they rely for food and shelter. Therefore, it is appropriate for these criteria to contain provisions designed to mitigate adverse effects of solid waste disposal activities on endangered and threatened species of plants, fish or wildlife.

The proposed criterion was designed to ensure that disposal activities did not occur in the critical habitats of endangered species unless it was determined that the activities would not jeopardize the continued existence of endangered species. The proposal also required the approval of disposal plans by the Office of Endangered Species (OES) in the Department of Interior (DOI).

Under Section 7 of the Endangered Species Act (ESA), as amended, 16 U.S.C. 1536, all Federal agencies, in consultation with the Secretary of the Interior or the Secretary of Commerce, are to utilize their authorities in furtherance of the purposes of the ESA. EPA held formal consultations with the DOI and received a "biological opinion" recommending changes in the criteria. EPA considered this recommendation from DOI and all public comments in setting this criterion.

EPA has concluded that the criteria should assure that no solid waste disposal facilities or practices cause or contribute to the taking of endangered or threatened species. Taking means harassing, harming, pursuing, hunting, wounding, killing, trapping, capturing or collecting, or attempting to engage in such conduct. In addition such activitites should not destroy or adversely modify the critical habitats of these species. EPA believes that this criterion is clearly within the scope of the Act and that it satisfies Agency responsibility under the ESA.

Some commenters questioned EPA's authority to address effects on endangered species in the criteria. The Act gives EPA authority to set criteria concerning the full range of health and environmental effects resulting from solid waste disposal. The taking of endangered or threatened species by solid waste disposal activities is certainly an environmental effect of concern. In addition the ESA places a responsibility on the Agency to use its authority under the Act to mitigate such effects.

The major change in this criterion from what was contained in the proposed regulation is the shift in concern to the *taking* of endangered and threatened species. The proposed regulation focused on avoiding modifications of critical habitats that *jeopardized the continued existence* of a species. After examining that approach in light of the comments, EPA decided that the "jeopardize" language was inappropriate for a definition that would be applied to a vast number of site-specific conditions. In deciding whether an act or facility would jeopardize the continued existence of a species, the officials implementing the criteria would have to examine the marginal effect that harm to particular members of a species would have on the national population of that species. Particularly in the case of the open dump inventory, which involves the evaluation of thousands of solid waste disposal facilities, it would be extremely difficult to implement a "jeopardize" standard.

A determination of whether disposal activities are "taking" endangered species is more readily applicable to the site-specific situations for which these regulations will be used. Officials charged with implementing the criteria, as well as parties engaged in solid waste disposal, can quickly determine what is necessary to achieve compliance. Such an approach is consistent with EPA's general intent to establish concise, measurable performance standards wherever possible.

The use of the "taking" concept does not reflect an EPA belief that the ESA requires such an approach. EPA's obligation under Section 7 of the ESA, if any, is to assure that the criteria, which provide a national definition of the unacceptable environmental effects of solid waste disposal, do not jeopardize endangered species. Where those criteria are applied by State agencies, such implementation activities are not subject to Section 7 because no Federal action is involved.

Some commenters suggested that in complying with Section 7 EPA could not set criteria applicable to non-Federal parties that are more restrictive than what Section 9 of the ESA now requires of such parties. (Section 9 prohibits the taking of endangered species.) EPA rejects that argument. The Act and Section 7 of the ESA give EPA authority to set criteria different than the requirements otherwise applicable under Section 9.

EPA believes that the best way to ensure that national populations of endangered and threatened species are not jeopardized is to avoid the destruction of members of that population in site-specific situations. While the standard could have been written several ways to accomplish that objective, EPA believes that preventing the "taking" of endangered and threatened species has several advantages. This approach will aid coordination between solid waste and endangered species programs where feasible. It also gives the regulated community a uniform standard defining its responsibility in both contexts. The "taking" definition is broadly stated and thus would encompass the variety of adverse effects on endangered and threatened species that could be caused by solid waste disposal. In its "biological opinion" DOI endorsed this approach.

In the proposed regulation EPA only addressed endangered species. Several commenters suggested that "threatened" species identified by DOI also be included for consideration. EPA believes that such threatened species of wildlife are also deserving of protection and, therefore, has included them in the criteria. Thus, the endangered and threatened species of concern are those listed under authority of Section 4 of the ESA.

In endorsing the "taking" language, DOI's "biological opinion" included exceptions for activities covered by permits under Section 10 of the ESA or allowed by Section 6(g)(2) of the ESA. Section 10 authorizes the issuance of permits for the taking of species "for scientific purposes or to enhance the propagation or survival of the affected species." The operative portion of Section 6(g)(2) makes the Section 9 prohibition of taking inapplicable in states that have negotiated cooperative agreements with DOI. Under cooperative agreement, designated State officials may take endangered species for conservation purposes. Since neither of these situations seemed applicable to solid waste disposal activities they have not been included in the criteria.

EPA has decided to retain that part of the proposed regulation that reflected a concern for the wildlife habitats. Where "critical" habitats of threatened or endangered species have been identified by DOI it is unacceptable under the Act for solid waste disposal activities to destroy or adversely modify such habitats. In setting this criterion EPA is not precluding all disposal in a critical habitat area. Only when such disposal appreciably diminishes the likelihood of the survival and recovery of threatened or endangered species using the habitat does a violation occur. The "biological opinion" from DOI endorses this approach.

EPA has decided to drop that portion of the proposed criteria which required approval of disposal plans by the Office of Endangered Species, Department of Interior. EPA agrees with the several commenters, including OES, who said that such a requirement was inappropriate. The Act and the CWA create the implementing mechanisms for these criteria. While the OES may, and probably should, be consulted on the application of § 257.3–2 to particular situations, the officials responsible for applying the criteria, rather than the OES, must determine whether a violation has occurred.

F. Surface Waters (Section 257.3–3)

It is essential that solid waste activities not adversely affect the quality of the nation's surface waters. Rivers, lakes and streams are important as sources of drinking water, as recreational resources and as habitats for a wide variety of fish and other aquatic organisms. The nation's coastal and inland wetlands provide natural flood and storm control, sediment and erosion control, recharge of acquifers, natural purification of waters, and flow stabilization of streams and rivers. Wetlands produce nutrients which support complex ecosystems extending into estuaries and streams well beyond the marshes and wetland areas. Wetland habitats support fish, shellfish, mammals, waterfowl, and other wildlife fauna and flora.

Solid waste disposal has led to surface-water contamination from runoff of leachate, accidental spills, and drift of spray occurring at dumps, landfills, surface impoundments, farmlands, and landspreading operations. In the proposed criteria EPA sought to coordinate its surface water standards under the Act with programs developed under the Clean Water Act (CWA) to restore and maintain the integrity of the waters of the United States (including wetlands.)

The proposed criteria required that point source discharges of pollutants comply with a National Pollutant Discharge Elimination System (NPDES) permit issued for the facility according to Section 402 of the Clean Water Act. A separate section addressed wetlands, a particular category of waters of the United States. This section, which has now been combined with the other surface water provisions, required that facilities not be located in wetlands unless permits were obtained under provisions of Section 402 and/or 404 of the Clean Water Act. The proposed criteria also required non-point source discharges of pollutants to be prevented or minimized.

The final regulation maintains this general approach and has eliminated those parts of the proposed regulation that might have created conflicting RCRA and CWA requirements concerning the adverse effects of solid waste disposal on surface waters. The separate section for wetlands was eliminated because they are treated like all other surface waters under the CWA. The provision affecting non-point source discharges to surface water has been linked more directly to applicable requirements developed for State and areawide water quality management planning programs under Section 208 of the CWA.

Under Section 1006 EPA is required to integrate, to the maximum extent practicable, the provisions of the Act with the Clean Water Act and other statutes. Under the CWA, EPA conducts programs designed "to restore and maintain the chemical, physical and biological integrity of the Nation's water." EPA believes that this goal is also a legitimate objective for its regulatory activity under the Act and that, in the spirit of Section 1006, EPA should use its authority under the Act to see that the goals of the CWA are achieved. Thus, in defining unacceptable solid waste disposal activities, EPA can and should determine that facilities and practices violating the Clean Water Act cannot be acceptable for purposes of RCRA.

Thus, in establishing the surface water criterion EPA used concepts and approaches used under the CWA. The surface waters of concern are the waters of the United States, which include "wetlands" meeting the Agency's and the Corps of Engineers' definition of that term. All point source discharges of pollutants must comply with requirements for NPDES permits pursuant to Section 402 of the CWA. Discharge of dredge or fill material to waters of the United States must comply with requirements for permits established pursuant to Section 404 of the CWA. ("Requirements" under the 402 and 404 permit programs include the general requirement to apply for such permits, as well as the substantive provisions of issued permits.) Non-point source pollution from solid waste disposal activities must not be in violation of legal requirements established to implement a water quality management plan under Section 208 of the CWA. Water quality standards developed to satisfy Section 303 of the CWA may be implemented through either NPDES permits, Section 404 dredge and fill permits, or legal requirements developed to implement a Section 208 plan.

Some commenters suggested that in using a CWA-based approach in these regulations EPA was attempting to regulate discharges to waters of the United States under the Act. This is certainly not the intent or result of these criteria. The implementation of CWA programs will be left to those responsible for those programs. In these criteria EPA is merely indicating that where solid waste activities violate the CWA, as determined by officials implementing that law, EPA cannot determine that those activities provide adequate protection to public health and the environment for purposes of RCRA.

Commenters also expressed concern over the definition of "wetlands", arguing that man-made channels and basins (particularly wastewater treatment lagoons) that happen to support vegetation should not be subject to protection under this criterion. In keeping with the goal of coordination, EPA is accepting the approach taken under the CWA, as expressed in the recently issued NPDES regulations (44 FR 32854). Thus, waste treatment lagoons or other waste treatment systems that happen to support vegetation are not waters of the United States. (As indicated in the NPDES regulations, cooling lakes and ponds are generally within the definition of waters of the United States, but certain kinds of cooling ponds may be excluded.)

Several commenters questioned the proposed inclusion of "surface runoff" as a point source discharge of pollutants. Under the existing NPDES regulations the term "discharge of pollutant" is defined to include "* * * surface runoff which is collected or channelled by man." EPA will maintain that approach in these criteria. All other surface runoff is subject to applicable requirements developed under section 208 plans for non-point source pollution.

Several public comments reflected concern about what permits would be necessary under the CWA for solid waste disposal in wetlands. Diking or other dredge or fill operations designed to prepare an area within waters of the United States for disposal of wastes would require a 404 permit as a matter of course. A question arises, however, concerning the actual deposit of the waste material into waters of the United States. Such a discharge could be treated as a discharge of pollutants requiring a Section 402 NPDES permit or as a discharge of dredged or fill material requiring a 404 permit.

Under previously issued regulations implementing the CWA (42 FR 37122), where the "primary purpose" of the discharge of waste material is for disposal, rather than for filling an area, the discharge is subject to the NPDES program.

Some commenters suggested a need for procedures establishing how NPDES permits will be applied to solid waste disposal. In response the Agency is developing policy guidance for this permitting process. As of this writing, a draft of this policy guidance, "NPDES Permits for Solid Waste Disposal Facilities in Waters of the United States—Policy Guidance Memorandum, August 23, 1978," has been distributed for external review. A public meeting for discussion of the draft policy guidance memorandum was held on December 11, 1978. EPA is currently reviewing the public comments submitted on this issue. EPA is also considering whether solid waste disposal in wetlands is more appropriately handled under the Section 404 permit program. EPA intends to explore this issue with the Corps of Engineers.

EPA has dropped any reference to a presumption against issuance of an NPDES permit for discharge of solid waste into wetlands. That reference, contained as a comment in the proposed regulation, reflected EPA's general belief that disposal activities should not be conducted in wetlands if other alternatives exist. The NPDES permit, however, will define the legal responsibilities of parties engaging in disposal of solid waste near or in waters of the United States. If the requirements of an applicable NPDES permit can be satisfied, then there will be no added "presumption" against the facility or practice.

Commenters raised concerns over the ability of NPDES permitting agencies to process applications and issue permits for point source discharges of pollutants from solid waste disposal facilities. It was noted that not many NPDES permits have been issued to such discharges.

It has been Agency policy to prioritize issuance of NPDES permits based on the potential adverse environmental impact of the discharge. However, all discharges require NPDES permits, and it is incumbent on the discharger to apply for the NPDES permit. Generally, no enforcement action is taken if application for an NPDES permit has been made, but the permit has not yet been issued. Upon issuance, the discharger must maintain compliance with the NPDES permit. Upon denial or revocation of a permit, the discharge must be discontinued.

In using the 208 planning program, EPA has dropped the proposed requirement to "prevent or minimize" nonpoint source pollution from solid waste disposal activity. Several commenters were concerned that such a requirement might duplicate or conflict with provisions developed to implement a State water quality management plan. EPA shares that concern and, therefore, has made the changes described above. However, EPA is also aware that not all 208 plans will have addressed the nonpoint source pollution problems presented by solid waste disposal. EPA intends to explore this problem further to determine whether uniform national guidance is needed and can be given on how to handle this type of pollution problem. If a set of standards can be devised EPA will consider amending these criteria.

Not all portions of a 208 plan will necessarily be applicable to solid waste disposal activities, and it will be up to officials implementing the criteria to make the appropriate determination. The criteria are linked only to those portions of the plan that have been translated into legal requirements (i.e. statute, regulation, ordinance, administrative orders.) This assures clarity on what is required, avoiding questions about how to comply with broadly-stated policy statements.

G. Ground Water (Section 257.3–4)

Ground water, generally a high quality, low cost, readily available source of water, is the drinking water source for at least one half of the population of the United States; often it is the only economical and high quality water source available. Ground water is generally suitable for human consumption with little or no treatment necessary.

Ground water has been contaminated by solid waste disposal on a local basis in many parts of the nation and on a regional basis in some heavily populated and industrialized areas, precluding its use as drinking water. Existing monitoring of ground-water contamination is largely inadequate; many known instances of contamination have been discovered only after ground-water users have been affected. The Act and its legislative history clearly reflect Congressional intent that protection of ground water is to be a prime concern of the criteria.

The proposed criteria established requirements for ground-water protection based on the utilization of the ground water. Ground-water utilization was divided into two categories: Case I addressed ground water currently used or designated for use as drinking water supplies or ground water containing 10,000 miligrams per liter (mg/l) total dissolved solids or less; and Case II addressed ground water designated for other uses.

For Case I, the proposed criteria required that the quality of ground water beyond the disposal facility be maintained for use as a drinking water supply. The proposed criteria were based on the "endangerment" approach adopted from previously proposed regulations for the Underground Injection Control Program (41 FR 36726). "Endangerment" was defined to mean introduction of a contaminant that would require additional treatment of current or future drinking water supplies or would otherwise make the water unfit for human consumption. The proposed criteria required that the disposal facility not "endanger" Case I ground water beyond the property boundary. (Comments were specifically requested on the use of other distances in lieu of or in addition to the property boundary.) For Case II, States could, where consistent with their authority, designate ground water for uses other than drinking water and would establish the quality at which the ground water was to be maintained consistent with the designated use.

In order to predict, as early as possible, the potential for ground-water endangerment, the proposed criteria required that ground water be monitored so as to indicate the movement of contaminants from the disposal facility where endangerment was likely. Contingency plans were required for corrective actions to be taken in the event that an adverse impact was indicated by the monitoring.

For sole source aquifers, the proposed criteria required that facilities not be located in the recharge zone unless alternatives were not feasible and unless "endangerment" was prevented.

Under the final ground-water criteria, the facility or practice must not *contaminate* an *underground drinking water source* beyond the *solid waste boundary or an alternative boundary* set by the State. Contamination occurs when leachate from the disposal activity causes the concentrations of certain pollutants in the ground water to either (1) exceed the maximum contaminant level (based on the primary drinking water standards) specified for that pollutant, or (2) increase at all where the background concentration of the pollutant already exceeds the applicable maximum contaminant level. An underground drinking water source is an aquifer currently supplying drinking water for human consumption or an aquifer in which the concentration of total dissolved solids is less than 10,000 milligrams per liter (mg/l). Generally, the existence of contamination is determined at the waste boundary. However, States with approved solid waste management plans may establish an alternative boundary if, after thorough examination of the site-specific situation, a finding is made that an adjustment of the boundary would not result in contamination of ground water needed or used for human consumption.

(1) *Approach to Ground-water Protection.* A few commenters suggested that the proposed regulation was beyond EPA's authority becaue it allegedly involved the establishment of ambient ground-water standards. This charge reflects a misunderstanding of the approach taken in the proposed, as well as the final, regulation. EPA is not regulating ground water with these criteria; rather, EPA is setting standards applicable to disposal of solid waste. In defining the unacceptable effects of such disposal on ground water, EPA has concluded that solid waste activities should not degrade ground water beyond levels established to protect human health. The criteria are designed to achieve that objective.

EPA recognizes that ground-water quality is important for other purposes (e.g. for irrigation of plants, for its effect on fragile ecosystems.) Differing standards may be appropriate to protect its usefulness for these other purposes. At this time, however, EPA has decided to define "contamination" in terms of the water's use as a drinking water source. EPA believes that the prevention of adverse human health effects from direct consumption of ground water, should be the first among several objectives in protecting ground-water quality. Moreover, the Agency has developed standards for drinking water but has not established standards for other uses.

These criteria reflect EPA's concern for both present and future users of ground water. A significant number of people in the country take their drinking water directly from ground-water resources. EPA expects that such direct use will continue in the future. In defining unacceptable solid waste disposal activities, these criteria cannot be based only on current patterns of ground-water use. Potential future users of the aquifer must be considered.

EPA believes that solid waste activities should not be allowed to cause underground drinking water sources to exceed established drinking water standards. Future users of the aquifer will not be protected unless such an approach is taken. Where maximum contaminant levels have already been exceeded due to other conditions or actions affecting the aquifer, solid waste activities should not be allowed to increase the risk of damage to present or future users of the aquifer.

(2) *Contaminants of Concern.* Commenters stated that the "endangerment" standard in the proposed regulation was vague, especially since it did not specify contaminants that would make more extensive treatment necessary or otherwise make the water unfit for human consumption. Some felt this approach would allow too much contamination, given the lack of certainty regarding toxicity of many contaminants and the state-of-the-art of monitoring and water treatment. Others stated that it would require facility operators to demonstrate protection from a myriad of substances, that the levels to which those substances should be tolerated was not defined, that the standard was based on unspecified treatment and changing technology, and that the capability of existing treatment is a function of too many parameters. In order to respond to these comments the Agency explored various lists of contaminants upon which to base the criteria.

Several reviewers supported the proposed criteria's use of the National Interim Primary Drinking Water Regulation (NIPDWR) in the definition of "endangerment". Some reviewers pointed out, however, that the list of contaminants in the NIPDWR (40 CFR Part 141) was not created to serve as ground-water quality standards, and that it does not include all potentially harmful substances which might be associated with leachate from solid waste.

EPA recognizes that the NIPDWR lists only those parameters commonly found in public drinking water supplies. Other substances which may be harmful to human health were not included in Part 141 due to their relatively rare occurrence in drinking water systems, the unsuitability of analytical methods, the high costs of monitoring, or the lack of toxicity data. For example, cyanide was not listed in the NIPDWR because of its low rate of occurrence. Several potentially dangerous substances which were excluded from the NIPDWR are present in leachate from waste disposal.

There is no doubt, however, that the contaminants identified in the NIPDWR are appropriate for consideration in the criteria. Generally, no commenters opposed the inclusion of any listed contaminant in this regulation. The one exception is the manmade radionuclides identified in the NIPDWR. These substances fall within the class of radioactive substances excluded from the Act's definition of solid waste and, thus, the leaching of these materials into ground water should not be addressed by these criteria.

EPA has evidence that all of the contaminants identified in the NIPDWR have been in wastes covered by these criteria and that such materials are likely to enter ground-water supplies. Therefore, while it may be advisable to expand the list of contaminants covered by the criteria as new information is developed by the Agency, it is certainly appropriate to use the contaminants identified in the NIPDWR in the criteria at this time.

The Agency has also explored the use of the National Secondary Drinking Water Regulations (NSDWR) in defining maximum contaminant levels. The NSDWR (40 CFR Part 143) represent the Agency's best judgment on the standards necessary to protect underground drinking water supplies from adverse odor, taste, color and other aesthetic changes that would make the water unfit for human consumption. EPA believes that this is a serious concern which deserves consideration in the criteria. In addition, many of the substances listed in the NSDWR often occur together with other substances in leachate which can be injurious to health.

However, EPA has decided not to include the contaminants identified in the NSDWR in the criteria at this time. It was not clear in the proposed regulation that EPA was considering their use for purposes of the criteria. To avoid any question about the adequacy of opportunity to comment on the use of the NSDWR in the criteria, EPA has decided to specifically seek public comment on this issue. Thus, EPA is also issuing today a proposed amendment to the criteria which would add the maximum contaminant levels in the NSDWR to the definition of ground-water "contamination."

Two other sets of pollution parameters were considered for inclusion in these criteria: the *Quality Criteria for Water* (EPA 1976) and the list of toxic pollutants referenced in Section 307(a)(1) of the Clean Water Act, as amended.

The publication *Quality Criteria for Water* recommends levels for water quality in accord with the objectives in Section 101(a) and the requirements of Section 304(a) of the Clean Water Act. The primary purpose of that publication is to recommend levels for surface water quality that will provide for the protection and propagation of fish and other aquatic life and for recreation. Although recommended levels are also presented for domestic water supply, and for agricultural and industrial use, ground water was not a major consideration.

Quality Criteria for Water lists most of the substances in Parts 141 and 143. Several of the additional parameters listed are only of interest in surface water protection, such as mixing zones (one third the width of a stream, 10 percent of the area of a lake, etc.), temperature, and suspended solids. While several health related substances that could be present in leachate are listed (e.g., boron, beryllium, cyanide, nickel and several insecticides and other organics), the recommended limits are specified for aquatic life protection and these are not appropriate for ground water. Furthermore, the recommended limits were written to be guidance in developing standards, not to be used as standards themselves. Therefore, EPA decided that this list was inappropriate for these criteria.

Under Section 307 of the CWA the Agency may establish either technology-based or stricter health-based standards for toxic pollutants identified under Section 307(a)(1). EPA is investigating the appropriateness of using the health-based standards in the criteria. Such substances as aldrin/dieldrin, DDT, endrin, toxaphene, benzidine and polychlorinated biphenyls (PCB's) are now subject to section 307 standards. EPA may be establishing such standards for other pollutants some time in the future. At this time, however, for purposes of these criteria, EPA will rely only on established drinking water standards.

(3) *Levels of Contamination.* While the design of the ground-water criteria is similar to the "endangerment" approach

of the Underground Injection Control Program under the Safe Drinking Water Act, it provides for greater specificity and does not use the exact wording of that program or statute. Therefore, to avoid confusion the term "endangerment" is no longer used in the criteria. Instead, the word "contaminate" has been employed. A facility "contaminates" ground-water if it introduces a substance that would cause:

(a) The concentration of that substance in the ground water to exceed specified maximum contaminant levels, or

(b) An increase in the concentration of that substance in the ground water where the existing concentration of that substance exceeds the specified maximum contaminant level.

The first part of the above definition is intended to protect water that can be used as drinking water without treatment. The second part is intended to protect ground water already at or above the maximum contaminant level by preventing introduction of substances that would exacerbate the problem.

Many comments were received on levels of contamination. Some suggested using the maximum contaminant levels (MCL's) in the National Primary and Secondary Drinking Water Regulations; others suggested using higher limits or using lower limits. Some reviewers suggested varying the levels with the background quality or the potential use of the ground water.

The reasons given for adopting higher allowable levels, or more lenient standards, (than the MCL's) included contention (1) that the increased cost of land disposal would be greater than the value of the threatened resource; (2) that the more efficient approach for some of the substances was to remove them from the water supply by treatment after contamination; and (3) that some of the Secondary MCL's are commonly exceeded in ambient or native ground water, thereby effectively resulting in a non-degradation standard for those aquifers. EPA sees no reason to doubt that some people will continue to consume ground water directly without treatment. That portion of the public should be protected from adverse effects (as defined by the drinking water standards) caused by solid waste leachate entering their drinking water. In some situations protection of the public will require non-degradation of an aquifer. The Act does not call for a balancing of the costs of disposal against the "value" of ground-water resources. EPA believes that this criterion represents a reasonable approach to ground-water protection. It allows for the use of natural mechanisms (e.g. soil attenuation, diffusion of contaminants in the aquifer) to reduce the risk of adverse health effects without compromising the general objective of protecting drinking water supplies.

The reasons given for more stringent limits included: (1) Land disposal facilities are but one of several sources of ground-water contamination, and each source contributes to the overall rise in contaminant levels, (2) future research may find that lower levels are necessary to adequately protect health, (3) some agricultural, industrial and other important uses of ground water may be impaired, and (4) since ground water is often consumed without treatment, more stringent limits would require less reliance on programs to monitor and to require treatment before domestic usage.

Generally, EPA has not written more stringent standards because existing information does not indicate that such standards are needed to protect public health. Future research results might, of course, justify changing the criteria. As discussed earlier EPA does not now have the scientific basis for setting stricter standards designed to protect ground-water's use for non-drinking water purposes. The standard does recognize that an aquifer may be polluted by several sources. Where existing ground-water quality levels exceed the MCL's, the solid waste activity may not degrade ground-water quality at all. No matter what the standard, the need for monitoring must be determined on a case-by-case basis, and it seems doubtful that differing standards would change that need.

Some reviewers mentioned that relying only on upper water quality limits results in more stringent requirements for protection of contaminated water than for uncontaminated water (i.e. facilities over uncontaminated waters could introduce substances up to the maximum contaminant levels, while facilities over contaminated waters could not introduce any substance that would increase contaminant levels). While this is a possible result of the standard, EPA does not believe that the health risk justifies a complete non-degradation standard.

In adapting the NIPDWR for the criteria a few modifications were necessary. As indicated earlier the standards for man-made radionuclides were not included because the statutory definition of solid waste excludes such materials from the Act's scope. The contaminant level for coliform bacteria had to be modified because under the NIPDWR the MCL varied somewhat depending on sampling frequency and community size. EPA assumed that sampling of ground water around disposal sites would be less frequent than in a public water system, and so the NIPDWR coliform standard related to the least frequent sampling regimen was selected for the criteria. Also, the criteria do not include the NIPDWR limit for turbidity, since that limit was established for surface water supplies.

(4) *Where the Standard is Applied.* Another concern regarding the ground-water criterion is the issue of where the standard is to be applied (i.e. at what point in the aquifer does contamination from the facility or practice constitute non-compliance). In the proposed criteria, the point of application was at the facility property boundary. The rationale for applying the standard at the property boundary was that it would provide for protection of off-site ground water while affording the opportunity for natural soil attenuation and dispersion and dilution of leachate in ground water underlying the area designated for waste deposition (i.e. within the facility).

However, the proposed criteria recognized that monitoring and control of leachate within the property boundary would generally be necessary in order to assure that the standard at the property bountary would be met. Therefore, there also were proposed operational requirements including monitoring of ground water, prediction and control of leachate migration, collection and removal of leachate and prevention of water infiltration.

Commenters indicated two potential shortcomings of the facility property boundary approach: (1) That future owners of the facility property might use contaminated ground water underlying the facility as drinking water and (2) that if the facility property were very large, great expanses of ground water could be contaminated and purchase of additional property could be used to circumvent the intent. EPA agrees that such results could occur.

Commenters also expressed concern that the operational controls and monitoring provisions were vague and could be meaningful only if specified on a site-by-site basis, rather than generally prescribed in a regulation of national applicability. Commenters also described these operational provisions as inappropriate to a regulation which must delineate acceptable performance levels.

The Agency considered use of other distance specifications in lieu of the property boundary in order to try to respond to reviewers' concerns about the potential for contamination of large expanses of ground water. The proposed criteria requested comments on alternative distances and the rationale for specification of such distances. Various distances were suggested in the public comments: however, there was no basis presented for selection of one distance over another. While there is a rationale for limiting migration of contamination to within the areas to be used for waste disposal in order to protect neighbors who may use the ground water untreated as a drinking water supply, there is no rationale for limiting migration to any *particular* distance.

In evaluating this issue EPA recognized that the point of application of the standard must be mindful of the ability to monitor at that point. Ideally, the best way to protect present and future users of an aquifer is to assure that drinking water standards are not violated anywhere in the aquifer, including the area immediately under the waste material.

However, any attempt to monitor directly under the waste presents two major difficulties. First, an environmental risk may be posed by the installation of monitoring wells through the waste material or in areas where waste will be deposited. These wells may become conduits for direct flow of waste constituents (e.g. leachate) into the aquifer. While it may be theoretically possible to construct a well that doesn't allow such infiltration, the technology for this has not been sufficiently demonstrated that EPA would want to encourage this practice on a national scale. Secondly, the immediate proximity of waste to the well, in conjunction with the "conduit" phenomenon, would undermine the utility of the monitoring well. Samples extracted would not be likely to be representative of the aquifer; rather, they would be likely to contain concentrated leachate, overestimating the contamination of the aquifer.

EPA also examined the possibility of other fixed distances from the center of the waste area. This approach was rejected because it was impossible to establish a uniform distance that would be meaningful for the vast number of situations to which this standard applied. In some instances a fixed distance would mean that monitoring wells would still be placed through waste material. A longer distance might, in some cases, put the point of measurement beyond the area of likely placement of drinking water wells.

After examining all of these approaches EPA concluded that the *solid waste boundary* is the appropriate point for application of the standard. The solid waste boundary is intended to be taken as the outermost perimeter of the solid waste as it would exist at completion of the disposal activity. With that as the point of measurement, ground-water contamination will be detected as soon as possible without presenting the risks inherent in monitoring under the waste. Likewise, it avoids the problem of guessing the distance at which a potentially affected party is likely to put a drinking water well. (The only assumption is that drinking water won't be taken from wells drilled directly through the area of solid waste deposition.)

In most cases, for disposal facilities, the solid waste boundary would be the boundary of the solid waste as shown on the design and operating plans which are provided to and approved by the State agency as part of the State's facility permitting or certification program. Where such plans do not exist to designate the perimeter at completion, especially for the practice of indiscriminate or unauthorized disposal, the perimeter at completion can only be taken as the current boundary of the deposited waste.

With this approach to the point of application for the MCL's, the monitoring requirements are relatively clear. Monitoring wells should be placed so as to avoid their becoming conduits for waste materials. Unsaturated and saturated zones underlying the area of the facility designated for waste deposition (i.e. within the solid waste boundary) may be employed for attenuation or control of leachate migration, but contamination of underground drinking water sources outside of these zones constitutes non-compliance with the criteria.

The point of application of the MCL's may be modified under certain circumstances. EPA recognizes that hydrogeological conditions, property rights or legal arrangements concerning an aquifer may limit the ability of the public to directly use some or any part of a particular aquifer as a drinking water source. EPA believes that some flexibility is needed in the criteria to provide for such situations. Therefore, the criteria allow the State to modify the point for application of the MCL's.

To prevent this from becoming a major loophole, the criteria establish limits to this flexibility. Only States with approved solid waste management plans may modify the point of measurement. This may only occur where the State has conducted a thorough examination of the site-specific situation and has made a specific finding that establishment of the alternative boundary would not result in contamination of ground water needed or used for human consumption. The examination leading to the finding should include the opportunity for public participation. The criteria specify the key factors that must go into this determination.

The proposed criteria would have allowed a State to designate an aquifer as a Case II aquifer (an aquifer designated for use other than as a drinking water supply). For an aquifer so designated, the proposed criteria required the ground water to be maintained at a quality as specified by the State. Several commenters challenged the use of this approach. Some argued that, given the uncertainties in future drinking water needs, all potentially usable drinking water should be conserved. They also pointed out that there was inadequate data on ground-water quantity, quality and use projections to make such designations and that institutions and authorities to make such trade-offs are non-existent. Commenters also suggested that it was improper for the criteria to defer totally to State standards for designated aquifers.

EPA generally agrees with the comments. These and other factors lead EPA to drop the aquifer designation provision and rely on the alternative boundary approach as the means for allowing flexible application of the criteria.

(5) *Underground Drinking Water Source*. The final criteria maintain the general approach found in the proposed regulation. The reference to aquifers that "may be designated by the State for future use as a drinking water supply" has been deleted. EPA concluded that this was unnecessarily vague. Any future drinking water source would be likely to fall within the second portion of the definition (aquifers in which ground water contains less than 10,000 mg/l total dissolved solids).

Some commenters questioned the use of the 10,000 mg/l total dissolved solids measure for usable aquifers. It is the Agency's general policy that ground-water resources below that concentration be protected for possible use as a drinking water source. This policy is based on the Safe Drinking Water Act and its legislative history which reflects clear Congressional intent that aquifers in that class deserve protection.

(6) *Sole Source Aquifers*. These aquifers are those which the Administrator specifically designates under authority of Section 1424(e) of the Safe Drinking Water Act (Pub. L. 93-523; 42 U.S.C. 300f, 300h-3(e); 88 Stat. 1660 et

seq.). This provision of the Safe Drinking Water Act is administered through regulations proposed as 40 CFR Part 148. As applied through RCRA, the Agency's concern for the impact of disposal facilities on these aquifers is not different from that for other underground drinking water sources as defined in the criteria. Therefore, for clarity and consistency, this area of the proposed criteria has now been incorporated into the ground-water section. Rather than addressing the location of facilities in recharge zones of such aquifers (an operational standard), the criteria apply the performance standard described above for all underground drinking water sources, including sole or principal drinking water sources, regardless of location.

H. Application To Land Used For The Production Of Food-Chain Crops (Section 257.3–5)

The conservation of the nation's natural resources is one of the Agency's highest priorities. The application of sewage sludge, as well as other solid wastes, to the land surface or incorporation within the root zone of crops may provide significant benefit through the addition of organic matter, nitrogen, phosphorus and certain other essential trace elements to the soil. Specifically, land application of solid waste coupled with good management techniques for enhancement of parks and forests and reclamation of poor or damaged terrain is a desirable land management technique.

Application of solid waste to agricultural lands may also be an environmentally acceptable method of disposal. However, when improperly managed, the application of solid waste to agricultural lands can create a potential threat to the human food chain through the entry of toxic elements, compounds, and pathogens into the diet. (It should be noted that pathogens are covered under the Disease section of the criteria.) In developing these criteria, the Agency attempted to achieve the benefits of resource conservation while at the same time providing for protection of public health and the environment. In recognition of the above public health concerns, the Agency prefers the application of solid waste to non-food-chain land rather than to agricultural lands. However, the Agency believes that food-chain land application practices which comply with these criteria will pose no reasonable probability of adverse effects on public health or the environment.

This section is only concerned with disposal activities affecting food-chain crops. The other sections of the criteria apply to all disposal activities, including those occurring on lands producing food-chain crops. However, solid waste facilities and practices are only affected by this section if the site of disposal is also a field for production of food-chain crops.

In their role as guidelines under Section 405 of the Clean Water Act the criteria define the responsibility of owners and operators of POTW's when they apply sewage sludge directly to the land. In an effort to encourage the beneficial use of sludge in small communities EPA is concerned that these criteria could present an unwarranted administrative burden upon such communities. Therefore, EPA will explore the possibility of reducing monitoring and recordkeeping requirements for those POTW's with small design capacity which do not have significant industrial inflow and which generate a sludge with a low contaminant level. Such reduced requirements for facilities which apply sludge to land used for the production of food-chain crops would be a part of future regulations or guidance designed to implement Section 405. EPA is considering using a design capacity of 1.0 million gallons or less per day to define "small" facilities and cadmium concentrations of less than 25 mg/kg (dry weight) to define "low-contaminant" sludge.

This section of the criteria is being issued today as an "interim final" regulation. This means that, while the regulation is "final" and legally enforceable, EPA is seeking further public comment on the regulation. If changes are warranted by suggestions or new information generated during the public comment period, EPA is quite willing to modify this section.

The "interim final" approach has been recognized by the courts as a permissible means for EPA to use when trying to satisfy the competing demands placed on its rulemaking efforts. Particularly where EPA is under court order to issue regulations by certain dates, this approach has been used to satisfy the spirit of the court's order without curtailing opportunity for additional public participation in the rulemaking process.

These criteria are subject to the mandate of the U.S. District Court for the District of Columbia in *State of Illinois v. Costle*, No. 78–1689 (D.D.C. Jan. 3, 1979). Under the order of that court the criteria were to be issued by July 31, 1979, and EPA intends to satisfy the spirit of that order. EPA believes that the standards established in this section provide a reasonable approach to the environmental problem at issue. However, the public has not had a full opportunity to comment on some of the technical data and analyses supporting this portion of the regulation. The "interim final" approach is appropriate because it allows the Agency to accommodate these two competing interests. It achieves substantial compliance with the court mandate while allowing full public participation in the rulemaking effort.

As proposed, this section of the criteria addressed four general categories of pollutants: (1) Cadmium; (2) pathogens; (3) pesticides and persistent organics; (4) ingestion of toxic organic chemicals and heavy metals (especially PCB's and lead). In the final regulation this section addresses cadmium and PCB's. Pathogens are considered under the disease criterion (§ 257.3–6). Lead, pesticides and persistent organics will not be addressed at this time because current information available to the Agency is inadequate to support specific standards. EPA will investigate the possibility of adding more pollutants to the criteria at a later date.

(1) *Cadmium.*—The proposed criteria included two approaches for the land application of solid wastes containing cadmium. The first approach incorporated four site management controls: Control of the pH of the solid waste and soil mixture; annual cadmium application limits that were reduced over time; cumulative cadmium application limits based on soil cation exchange capacity (CEC); and a restriction on the cadmium concentration in solid wastes applied to facilities where tobacco, leafy vegetables and root crops are grown. The second approach required comparability of the cadmium content of crops and meats marketed for human consumption to the cadmium content of similar crops and meats produced locally where solid waste had not been applied. Also, a contingency plan was required which identified alternative courses of action that would be taken if the cadmium levels were not found to be comparable. This approach was only available to facilities possessing the necessary resources and expertise to adequately manage and monitor their operations to assure such comparability.

In the final regulation, application of solid waste to land is specified as a disposal practice in which the solid waste is applied to within one meter (three feet) of the surface of the land. That distance was selected to represent the root zone of food-chain crops, where uptake of cadmium by plants is likely to occur.

The final regulation maintains the same general approach as the proposed regulation. Under the first option controls are placed on both annual application rates and maximum cumulative loadings. The provision mandating that the pH of the mixture of soil and solid waste be maintained at 6.5 has been changed to a requirement that the pH be at 6.5 or more at the time of each solid waste application (except when cadmium concentrations are 2 mg/kg or less in the solid waste).

While the annual application rate limits are basically the same as those in the proposed regulations, two changes have been made. The limit for annual cadmium application to "accumulator" crops is now 0.5 kilograms per hectare/yr. (In the proposed regulation the limit was expressed in milligrams per kilogram dry weight of waste.) In addition, the annual application rate limit for all other crops will be phased in over a slightly longer time period than that which was proposed.

The limits on cumulative loadings are also basically the same as those in the proposed regulation. However, they have been modified to account for pH effects. Where natural soil background pH is at 6.5 or greater, or where the natural soil background pH is less than 6.5 but safeguards exist at the site which will assure that the soil pH will be maintained at 6.5 or greater for as long as food-chain crops are grown, the maximum limits contained in the proposed regulation are applicable. In all other situations maximum cumulative loadings may not exceed 5 kg/ha.

As in the proposed regulation, there is a second approach that would allow unlimited application of cadmium providing that four specific control measures are taken: First, the crop grown can only be used as animal feed. Second, the pH of the soil must be maintained at 6.5 or above for as long as food-chain crops are grown. Third, a facility operating plan must describe how the animal feed will be distributed to prevent human ingestion. The plan must also describe measures that will be taken to prevent cadmium from entering the human food-chain due to alternative future land uses of the site. Fourth, future owners are provided notice (through provisions in land records or property deed) that there are high levels of cadmium in the soil and that food-chain crops should not be grown.

EPA received many comments on the cadmium controls in the proposed regulation. In order to clearly explicate the final standard and respond to major public comment, this preamble will discuss the issues under five headings: (a) Health effects; (b) trace amounts of cadmium; (c) maximum cumulative loadings; (d) annual rates of application; and (e) closely controlled facilities.

(a) *Health Effects of Cadmium.*—The comments that were received exhibited widely divergent views on the health implications of cadmium contained in solid waste. As a result, the Agency reexamined the available scientific data and reached the following conclusions.

A variety of adverse health effects have been documented in humans and experimental animals under conditions of acute as well as chronic exposure to cadmium. While acute health effects in humans are generally caused by high-level occupational exposure through inhalation, chronic health effects may result through the diet and cigarette smoking, which are the major routes of cadmium intake for most people. The kidney is considered the main target organ for chronic exposure to cadmium, although chronic respiratory effects have been observed in long-term occupational settings. Upon ingestion or inhalation, the metal gradually accumulates in the kidney cortex. According to both clinical-epidemiological and model-calculation data, the critical concentration of cadmium in the kidney cortex is approximately 200 micrograms per gram (ug/g), wet weight, in the average human. At that level, renal tubular dysfunction, characterized by proteinuria, is expected to occur. This condition is manifested by the excretion of B_2-microglobulin, which is the earliest discernible laboratory evidence of organ damage. Although mild or moderate increases in excretion of B_2-microglobulin, per se, are not life-threatening, the condition is often irreversible, and continued excessive exposure to cadmium can lead to other renal function abnormalities (such as glycosuria, amino-acid uria, and phosphaturia).

Several autopsy studies have been performed to determine the cadmium content of various types of body tissue, such as the kidney and the liver. These studies confirm that the kidney is the organ which contains the highest concentration of cadmium and that the concentration of the metal increases with age. Further, the autopsy data indicate that for the general United States population (smokers included) the mean cadmium levels reached in the kidney cortex are in the range of 20–35 micrograms per gram wet weight. Smoking would tend to raise the mean cadmium concentration since the data also show that smokers have approximately double the concentration of non-smokers. There were significant individual variations from the mean value, with some concentrations over 60 micrograms per gram.

Various models have been established to calculate the daily level of exposure which will result in a cadmium concentration of 200 ug/g in the kidney cortex, i.e., the concentration at which tubular proteinuria can be expected to occur. EPA scientists reviewed these models and have reached the following consensus. Ingestion of 440 micrograms of cadmium per day over a 50-year period is a reasonable estimate of the amount of cadmium necessary for 50 percent of the individuals within the population to develop proteinuria. It is significant to point out, however, that there are many individuals who may develop proteinuria at lower exposure levels. The metabolic model, developed by Friberg, shows that ingestion of about 200 micrograms per day over a 50-year period is the level at which most sensitive individuals accumulate 200 ug/g cadmium in the kidney cortex. The dose-response model, developed by Kjellstrom and Nordberg, reflects a non-threshold dose-response. Using this model, daily cadmium exposures in the range of 100 to 125 micrograms would produce renal dysfunction in about 5 to 8 percent of the population after some 50 years of exposure.

These model calculations are based on the assumption that all cadmium intake is through the diet. Therefore, allowances are necessary for non-dietary routes of cadmium intake, such as smoking or occupational exposure. (The contribution of smoking to cadmium intake is readily quantifiable. Available data show that smoking one pack of cigarettes a day is roughly equivalent to cadmium retention in the body resulting from a dietary intake of 25 micrograms.)

In 1972, the World Health Organization (WHO) used a model such as the ones referred to above to arrive at a recommended maximum cadmium intake level through the diet. Employing a margin of safety to allow for non-dietary intake sources and for sensitive individuals, the WHO recommended that human exposure to cadmium should not exceed 57 to 71 micrograms per day from the diet.

There is no general consensus on the current dietary cadmium levels in the United States, but there is wide agreement that the daily intake levels vary significantly according to individual dietary habits. Based on annual market basket surveys conducted by the Food and Drug Administration (FDA), the median ingestion level is about 39 micrograms per day and the mean ingestion level is about 72 micrograms per day for male teenagers, who have the highest per-capita food intake among any age group. Any average value as an estimate for cadmium intake through the diet has the shortcoming that it does not represent those individuals with unusual dietary habits, such as the heavy consumption of cadmium-rich foods (e.g., leafy vegetables); and the available evidence shows that there is a wide range of dietary cadmium exposure among the population.

One other source for estimating cadmium intake levels in the human body was reviewed by the Agency. This comprises chemical analysis of fecal excretions. The fecal excretion studies are based on the experimental finding that only about 6 percent of ingested cadmium is retained in the body, while the rest is excreted. Three recent fecal excretion studies derived the daily mean dietary cadmium intake estimate of about 20 micrograms for American teenage males. The reasons for the significant differences between the results of the fecal excretion studies and the FDA market basket surveys are not yet understood. The fecal excretion studies also showed significant individual variations in derived cadmium ingestion levels. Thus, five percent of the population appeared to exceed 30 to 40 micrograms per day intake, and one percent appeared to exceed 50 micrograms per day intake.

There are population groups for whom an increase of cadmium levels in the diet may be more significant than for the average population. Among these are the smokers, who are known to receive an added body burden of cadmium via inhalation. Vegetarians also may be experiencing higher cadmium intake than the average population, since certain vegetables contain significantly more cadmium than other food items. Also, the scientific literature indicates that certain nutritional deficiencies, such as low calcium, zinc, or protein, result in a marked increase in cadmium absorption through the gastrointestinal tract, while individuals with vitamin D deficiency are more susceptible to injury by a given level of cadmium in the body.

Both the FDA approach and the fecal study approach are legitimate means of estimating current average intakes of cadmium. However it is also clear that "sensitive" individuals may be experiencing much higher absorption of cadmium. Since under this regulation higher estimates of current intake will mean that lower levels of cadmium will be allowed to be added from solid waste disposal, EPA believes that it should use the higher estimate of current diet levels in order to provide greater protection for sensitive individuals. Therefore, as will be explained later, the criteria will rely on the FDA estimate of 39 ug/day as the median level in the diet, which was derived by averaging the median levels over several years.

In addition to the concerns over renal toxicity, several commenters raised questions over potential oncogenic, carcinogenic, mutagenic and teratogenic effects of cadmium. Based on an evaluation of the currently available scientific data, the Agency has concluded that the evidence that cadmium may cause these effects in man is suggestive but not decisive enough to serve as the basis for this regulation. Consequently, the limitations on cadmium incorporated in the criteria are based on the substantial evidence of that metal's impact on the kidney, specifically the renal cortex, which the Agency considers to be the main target organ for chronic environmental exposure. However, if cadmium is determined to cause the aforementioned effects in humans, the Agency will reevaluate the regulations and establish appropriate new limits.

The Agency is concerned over the conduct of any practice which could significantly increase the amount of cadmium in the diet beyond current levels. Therefore, it is the intent of this rulemaking to minimize the movement of cadmium into the human food chain from solid waste applied to the land. After an evaluation of the full range of scientific information concerning cadmium, EPA has decided to make the following assumptions to serve as a basis for setting limits on solid waste application.

First, the Friberg model, which defines 200 ug/day as the "danger level" in the human diet, is most appropriate for regulatory purposes. There is more data to validate that approach than there is for the Kjellstrom dose-response model.

Second, to provide an adequate safety margin in defining the risk from solid waste applied to food-chain crops, the criteria should be concerned about daily dietary intake of 70 ug/day of cadmium.

Third, for analytical purposes, EPA will assume a maximum increment of 30 ug/day in conjunction with high risk diet assumptions. In order to relate the health effects analysis to the diverse and complicated data that exist on crop uptake, it is necessary to make a judgment about the incremental cadmium ingestion that must be prevented by this regulation. Clearly, this is a difficult task in light of the various sensitivities of particular individuals, the long-term nature of the health risk and the various dietary patterns which may occur.

In using this assumption, EPA is not stating that such an increase in the diet of the average American is acceptable. An increase of that magnitude in the *average* diet would clearly be unacceptable. For the average to increase by this increment, many individuals would be experiencing much higher cadmium intakes.

It must be emphasized that the 30 ug/day figure will be used in an analysis of a high-risk situation. That high-risk situation is one where an individual receives 50% of his vegetable diet from sludge-amended soils for a period of 40 to 50 years. While such a situation could occur, due to a wide variety of other mitigating factors most people will experience much smaller exposures to cadmium.

Realizing that any numerical expression of unacceptable health risk can only be an approximation, EPA used the 30 ug/day as a reasonable assumption for this analysis. The Agency's Office of Research and Development determined that daily cadmium intake of about 200 ug/day could lead to serious health effects. To provide a margin of safety, that office suggested that a limit of 150 ug/day from all sources of exposure be considered for regulatory purposes. EPA is also concerned about the added cadmium which may enter the human body due to smoking. Heavy smokers (those smoking 3 packs of cigarettes per day) can expect to add the equivalent of 75 ug of cadmium to their daily intake.

Reducing the 150 ug/day by that figure gives an estimate of the "danger level" for dietary intake. The result of that calculation (75 ug/day) is close to the World Health Organization's recommendation of 57–71 ug/day. EPA decided that a level of 70 ug/day represented a reasonable limit on the maximum acceptable daily dietary intake of cadmium. The FDA's estimate of current levels of cadmium in the median American is 39 ug/day. Therefore the 30 ug/day assumption would keep cadmium ingestion within the limit of 70 ug/day.

(b) *Trace Amounts of Cadmium.*—Where the cadmium content of sludges is quite small the likelihood of a significant uptake in plants is also relatively small. Several commenters suggested that the requirement for pH control (6.5 at time of waste application) should not apply to those solid wastes which contain only trace amounts of cadmium. EPA agrees with this comment and, therefore, has exempted wastes with cadmium concentrations of 2 mg/kg (dry weight) or less from the pH control provision. This modification would allow such wastes as food processing residuals to be landspread without unnecessary pH control measures.

(c) *Maximum Cumulative Loadings of Cadmium.*—Comments received on the cumulative cadmium application limits, soil pH, and soil cation exchange capacity (CEC) are interrelated and, therefore, will be discussed concurrently. In general, commenters felt that varying degrees and combinations of the three aforementioned parameters will limit the uptake of cadmium by food-chain crops.

Most commenters agreed that it is necessary to control the pH of the solid waste/soil mixture to minimize the uptake of cadmium by food-chain crops. The final regulation recognizes that need by requiring that the pH of the soil/solid waste mixture be 6.5 at the time of application. The proposed regulation required that pH be maintained at 6.5 for as long as food-chain crops were grown. Several commenters pointed out that such a provision would be difficult to implement or enforce in many situations. The Agency agrees that this may be true in some instances but did not want to preclude the application of solid waste to food-chain crops where soil pH can be maintained at acceptable levels.

These considerations prompted EPA to modify the standard for cumulative loadings to delineate three soil categories based on pH: (1) Those with natural pH of 6.5 or above; (2) those with natural pH below 6.5; and (3) those with natural pH below 6.5 but where pH will be maintained at or above 6.5 for as long as food-chain crops are grown. The criteria establish the same set of standards for categories (1) and (3) but tighten the standard for soils with the more dangerous condition reflected in category (2).

The prime data base for the calculation of acceptable cumulative loadings was a set of field studies on former landspreading sites where crops were grown at least two years after application of solid waste. This approach was appropriate for setting maximum cumulative limits because such standards are primarily concerned with future uses of landspreading sites for home gardening or commercial agriculture.

These data correlated cumulative loadings of solid waste in the soil to plant uptakes of cadmium in representative leafy vegetables. From existing data comparing uptakes of leafy vegetables to other basic food classes, EPA calculated the ratio of uptakes in leafy vegetables to those in other classes. The ratios were then applied to the field data to predict what uptakes would have been if other types of crops had been grown on former landspreading sites. This gave an estimate of cadmium uptakes that would be likely to occur in fields with differing cumulative levels of cadmium.

EPA then used a "diet scenario" analysis to translate the plant uptake levels into predictions about the amount of cadmium entering the human food chain. The Agency's assumptions about intake of the various food classes followed that of the U.S. Food and Drug Administration's 1974 Total Diet Studies. From this, EPA calculated the additional cadmium entering the human diet, assuming varying levels of dependence on crops from waste-amended fields. (EPA calculated intakes for situations where 100%, 50%, 25% and 10% of the diet come from such fields.)

The 5 kg/ha limit for acid soils (below 6.5 pH) was established by relating the diet scenario analysis to the health effects analysis. The diet scenario analysis indicated that on mildly acid soils (pH=5.8) 5 kg/ha of cadmium only increased dietary cadmium by 22 ug/day (making the assumption that no more than 50 percent of one's vegetable diet is derived from sludge fields). However, a cumulative loading of 7 kg/ha on very acid soils (pH=4.9) increased the dietary level by 211 ug/day. This marked increase in dietary cadmium may be attributed to both the increase in the cumulative cadmium application rate from 5 kg/ha to 7 kg/ha and the drop in pH from 5.8 to 4.9. Such an increase is far above the acceptable level in the diet. Therefore, EPA has established the maximum cumulative limit at 5 kg/ha for acid soils.

Soil cation exchange capacity was also utilized in calculating the permissible loadings for soils with pH of 6.5 or greater. The evidence available to EPA indicates that CEC is an important index of soil factors in limiting uptakes in high-pH soils. However, in highly acidic soils, pH becomes the dominant factor affecting plant uptake.

Soil CEC is an easily measured index of those properties, particularly the nature and content of clay and organic matter, that affect the soil's ability to adsorb cadmium. High CEC levels mean that a soil has a greater capacity to adsorb cadmium and thus prevent that cadmium from entering plants grown in the soil. Several studies have demonstrated the inverse relationship between CEC and plant uptake of cadmium.

The proposed cadmium standard recognized the importance of CEC and established differing limits depending on CEC levels in the background soil. The actual numbers selected were based on recommendations from recognized agricultural research groups (including the North Central Regional Extension Services and the U.S. Department of Agriculture). Several commenters supported the selected levels as providing adequate protection against excessive uptake of cadmium.

Where possible, EPA also used existing field studies on former landspreading sites to validate those recommendations. An application of the diet scenario analysis to available data on high-pH soils with mid-range CEC's supports the conclusion that the levels established in the recommendations provide adequate protection to the public. As an example, again assuming that half of the vegetable diet comes from sludge-amended fields, the data show that a cumulative level of 7 kg/ha could result in an 11.9 ug/day dietary increment, while a level of 15 kg/ha could result in a 39.2 ug/day increment. Using the 30 ug/day increment assumption discussed previously, the 15 kg/ha loading is too high, while the 7 kg/ha loading is well within the acceptable range. EPA believes that this analysis supports the selection of 10 kg/ha is an appropriate standard for soils with a mid-range CEC. In light of the other clear evidence of the role of CEC in limiting uptake EPA believes that it is, therefore, appropriate to use the limits recommended by the research community.

The Agency recognizes that there are some facilities with naturally acid soils where land management practices can be implemented with adequate safeguards to assure that the soil pH will be maintained at 6.5 or higher for as long as food-chain crops are grown. Where such safeguards exist, the criteria provide an option to permit such facilities to use the CEC-based cadmium loading rates. However, the Agency is concerned that the application of up to 20 kg of cadmium per hectare may result in significant cadmium uptake by crops if the pH is not controlled for as long as food-chain crops are grown. Therefore, unless the facility can clearly demonstrate long-term control over pH, the Agency strongly recommends that those facilities having naturally acid soils select the option which limits the cumulative cadmium application rate to 5 kg/ha.

The Agency considered establishing even lower cumulative cadmium application rates on soils with a natural pH that is very highly acidic (including prohibition on landspreading on soils with very low pH). While it is clear that leafy vegetables, root crops and tobacco tend to accumulate cadmium in their tissues and, therefore, are more sensitive to high soil cadmium concentrations under acid soil conditions, insufficient data exist to establish more restrictive cumulative levels for such soils. The Agency is continuing to examine this situation and will, upon development of additional data and information, propose new cumulative limits for highly acidic soil. However, in recognition of the higher uptake of cadmium by these crops, the Agency recommends avoiding the application of solid waste containing cadmium (e.g., sewage sludge) on very acidic soils used for the production of leafy vegetables, root crops and tobacco and discourages the application to agricultural land which is likely to be converted to production of such crops.

The Agency also considered requiring a soil analysis for total cadmium prior to the application of solid waste and adjusting the cumulative limit for cadmium additions downward to account for soils with high background cadmium concentrations. However, the Agency was not able to justify the use of a background correction factor since there is a paucity of data concerning the relationship between naturally occurring cadmium and solid waste-added cadmium, with respect to crop uptake. Until these questions are resolved, the Agency recommends that a soil test be performed prior to initiating landspreading, in order to establish the background conditions at the site. Further, for those facilities which have unusually high background cadmium soil concentrations, the Agency recommends that consideration be given to reducing cadmium application.

(d) *Annual Cadmium Application Limit.*—Comments received on the proposed annual cadmium application limits were widely divergent. Several commenters stated that the proposed cadmium limitation of 0.5 kilogram per hectare (kg/ha) per year was unnecessarily restrictive. The indicated reasons were primarily that the reduction in solid waste application would result in increased costs and that the potential risk to human health was not sufficient to justify that reduction. A second group of commenters suggested that the annual limitations on cadmium application were not sufficiently protective of public health and should be reduced much further or the application of cadmium-containing solid waste to agricultural lands be prohibited altogether, since the proposed limits would permit the entry of significant quantities of cadmium into the human diet.

Comments were also received on the proposed cadmium concentration limit of 25 mg/kg for solid wastes applied to facilities where tobacco, leafy vegetables or root crops are grown for human consumption. Some commenters viewed the proposed limit as being overly restrictive, while others recommended that cultivation of those crops which tend to accumulate cadmium to relatively high levels should not be allowed on waste-amended soils.

EPA believes that annual cadmium application limits are particularly important on those active sites which are nearing the cumulative cadmium application limits. As the total amount of soil cadmium at such sites begins to reach the cumulative loading limits, both the cadmium previously applied to the soil and new additions of cadmium from solid waste will affect crop uptake of cadmium. In setting annual application rates EPA must account for this factor.

Available research indicates that there are significant differences in uptake among crop species. It would, however, be impossible to write specific cadmium limits for each crop type based on the available data. Moreover, such an approach would complicate the regulation, making implementation confusing and impractical.

In looking at individual crop uptakes, however, EPA determined that there is a set of "accumulator" crops which tend to absorb very large quantities of cadmium as compared to all other crops. Tobacco, leafy vegetables and root crops constitute the "accumulator" class. In order to provide an adequate margin of safety EPA believes that the annual application rates should be based on data from representative "accumulator" crops. This assures that when a mix of crops is grown on sludge-amended fields no crop will have dangerous up takes of cadmium.

The available data indicates that significant increases of cadmium occur even with small applications of waste. For example, annual rates of approximately 0.7 kg/ha applied to soils which have not received sludge previously have been shown to triple the amount of cadmium in lettuce leaves. Using the diet scenario analysis it can be demonstrated that application rates of 0.8 kg/ha can lead to dietary increases of 10.3 ug/day from leafy vegetables alone. Other data indicate that this level may be even greater where cadmium from landspreading in previous years is already in the soil. Under these circumstances EPA concluded that an annual limit of 0.5 kg/ha is necessary to provide adequate protection to the public health.

EPA recognizes that not all crops will present the same risk as accumulator crops, particularly in the first few years of landspreading. However, due to the factors discussed above, applications of solid waste should eventually be limited to 0.5 kg/ha for all food-chain crops. Therefore, the Agency has decided to distinguish between accumulator and non-accumulator crops in the annual limits. When wastes are applied to accumulator crops the annual limit will be 0.5 kg/ha immediately. For all other crops a phased reduction will be allowed.

The criteria limit additions to 2.0 kg/ha until June 1984 and 1.25 kg/ha until December 1986. This gives communities and industry the time necessary to implement programs, such as cadmium source control and pretreatment of industrial discharges, to reduce current cadmium concentrations in their wastes or to develop alternative disposal practices. The schedule has been slightly relaxed from the proposed criteria in order to make it compatible with the Agency's pretreatment program schedule. The Agency believes that allowing higher cadmium application rates than 0.5 kg/ha through 1986 will have a negligible human health effect because the health impacts from cadmium are long-term and cumulative in nature. Based on assumptions similar to those used in the "diet scenario" analysis (see the discussion of cumulative loading limits), it can be shown that during this initial period applications of 2.0 kg/ha do not present significant health risks.

The proposed regulation also distinguished between accumulator and non-accumulator crops, and that approach is being maintained in the final criteria. However, the proposed limit for accumulator crops was expressed in terms of sludge quality (cadmium concentration in the waste not to exceed 25 mg/kg dry weight). Calculations show that a cadmium concentration limit of 25 mg/kg in the solid waste will not necessarily preclude application rates above 0.5 kg/ha, the level which EPA believes is more directly related to the human health risk.

For example, some solid wastes are often applied to the land as soil conditioner or mulch. Such a solid waste (e.g., composted sewage sludge), at a cadmium concentration of 25 mg/kg, would contribute cadmium to the soil at the rate of about 1.5 kg/ha when applied 1.3 cm (0.5 inch) thick to the land surface. Therefore, EPA decided to integrate this standard with the rest of the section and express the limit in kg/ha.

(e) *Closely Controlled Facilities.* Substantial public comment was received on the second major approach proposed for controlling dietary intake of cadmium via the application of solid waste to land. This approach required cadmium levels in crops or meats produced from solid waste-amended soils to be comparable to cadmium levels in similar crops or meats produced locally where solid waste had not been applied. Several commenters stated that this approach would be very difficult to implement because of problems in establishing an effective system to monitor and control agricultural products. Moreover, terms such as "local market" and "comparable levels" are vague and, therefore, subject to varying interpretations.

Commenters suggested two major alternatives to the proposed approach; both of these were considered by the Agency. They were dilution of cadmium-containing crops and meats in the market place, and establishment by the FDA of maximum permissible levels of cadmium in food products. Dilution in the market place was not selected as a control option, partly because of the difficulty of implementation. More importantly, the dilution of a toxic contaminant into the food chain is an unacceptable long-term policy because it could, over a number of years, significantly increase the total body burden in humans.

The FDA indicated that the alternative approach of establishing a tolerance level for cadmium in food products is not possible at this time because of insufficient data. A nationwide survey is being conducted currently by the EPA, FDA, and USDA on cadmium levels in raw agricultural commodities; however, several years will be required to obtain the statistically meaningful data necessary to establish tolerance levels in agricultural crops.

Based on the public comments received, the proposed criteria have been modified to simplify implementation yet still provide adequate health protection. As promulgated, this cadmium management approach sets forth four requirements which will serve to minimize the increase of cadmium in the human food chain.

First, only animal feed may be grown under this option. Research data show that animals excrete most of the ingested cadmium; the small amount that is absorbed is accumulated in viscera such as the kidney and the liver. The likelihood of significantly increasing individual or general dietary cadmium levels through animal feeds is negligible. Several commenters suggested that the Agency consider prohibiting the marketing of livers and kidneys of such animals for human consumption. There is some question whether such an approach is within EPA's authority under the Act. Moreover, control of distribution in this manner is unnecessary because the marketing of organs from such animals would not result in a significant increase of cadmium in an individual's diet.

The second control to assure proper management of the facility is the requirement that the solid waste and soil mixture have a pH of 6.5 or greater at the time of solid waste application or at the time the crop is planted, whichever occurs later. The Agency believes that maintaining the soil pH at a near-neutral level is particularly important under this cadmium management approach where the cadmium application rate is unrestricted.

The third requirement calls for the development of a facility operating plan. The purpose of this plan is to demonstrate how the animal feed will be distributed and what safeguards are utilized to prevent the crop from becoming a direct human food source. EPA is primarily concerned about crops such as corn, wheat and soybeans which may be used for animal feed or direct human ingestion. In addition, the facility operating plan should describe the measures that have been taken to safeguard against possible health hazards resulting from alternative future uses of the land. Some future land uses, such as the establishment of vegetable farms or home vegetable gardens, could result in significant dietary increases of cadmium. Such provisions in the facility operating plan could cover a range of options, such as dedication of the facility as a public park, placement of fresh top soil over the site, or removal of the contaminated soil.

The fourth requirement is a stipulation in the land record or property deed which states that the property has received solid waste at high cadmium application rates and that foodchain crops should not be grown, due to a possible health hazard.

(2) *Poly-chlorinated Biphenyls (PCB's).* The proposed criteria required that solid waste containing pesticides and persistent organics, when applied to land used for the production of food-chain crops, not result in levels of these substances in excess of the tolerances set pursuant to the authorities of the Federal Food, Drug and Cosmetic Act. The proposed criteria also required that solid waste of concern due to its toxic organic chemical or heavy metal content (e.g., PCBs and lead) not be applied to a site so that the freshly applied solid waste may be directly ingested by animals raised for milk or by humans.

At this time, EPA has decided not to establish tolerances for pesticides and persistant organics in solid waste. They were not developed because there were no adequate data on the amounts of these substances in solid waste to demonstrate a public health risk. An ongoing study is expected to obtain information on the amount of pesticides and persistent organics in sewage sludge to help develop a standard relating to this subject. After reviewing existing FDA tolerance limits for such substances, EPA has determined that they are impractical as a basis for standards for solid waste application to food-chain lands, because those tolerance limits are based on food contamination from pesticide application. At this time there is almost no information available indicating the relationship between the level of such substances in solid waste and the resulting food contamination. Direct application of the FDA tolerance limits would require extensive chemical analysis for a very large number of pesticides and toxic organic substances that might be present in the solid waste in trace amounts. Other data sources also did not provide an adequate basis for setting standards. The Agency will continue to evaluate data on this subject and explore this problem with the FDA and other interested parties. It is possible that standards on this subject could be part of pending sewage sludge disposal guidelines under Section 405 of the Clean Water Act, as well as future amendments to the criteria.

While EPA is concerned about the health problem posed by ingestion of lead, the Agency is not aware of any evidence that increased lead ingestion by dairy animals results in elevated lead levels in milk. Consequently, the Agency is not able to promulgate a standard for lead based on ingestion of solid waste by dairy animals, as was suggested by some commenters. While direct ingestion of lead by children, which may occur when they play in areas where sludge has been applied, may also be a concern, there is limited data available to establish a standard for this situation. The Agency intends to explore this potential problem further in the pending sewage sludge disposal guidelines under Section 405 of the Clean Water Act.

In establishing the standard for PCB's, the Agency looked to tolerance levels established by the FDA to define the health risk. The FDA has established maximum tolerance levels of 0.2 mg/kg (actual weight) for animal feeds and 1.5 mg/kg (fat basis) for milk. The standard promulgated in the criteria is designed to prevent PCB levels from exceeding these levels due to application of solid waste to fields growing animal feed. When solid wastes are applied to the land surface so as to allow direct contact between the solid waste and the crop, the animal feed can become contaminated. By incorporation of the solid waste beneath the soil surface (generally below the root zone of pasture grasses), the amount of ingested PCB's is greatly reduced. Therefore, EPA has concluded that the proper regulatory strategy is to require incorporation of the solid waste into the soil when the PCB level in the waste material is so high that direct contact between the crop and the soil could cause the FDA tolerances to be violated.

Based on assumptions recommended by FDA, EPA calculated the concentration level of PCB's in solid waste which might cause the FDA tolerances to be violated. These calculations established the PCB concentration threshold at 10 mg/kg. Generally, then, any sludge which exceeds that level of PCB's must be incorporated into the soil when applied to land used for the production of food-chain crops.

There is, however, one exception to that requirement. Wastes which exceed 10 mg/kg of PCB's may be applied to fields without incorporation if testing of the animal feed grown on the field demonstrates that the FDA standards will not be violated. If such testing indicates that the FDA standards have been violated, then the solid waste disposal activities leading to the contamination have violated the criteria.

It should be noted that the calculation of the 10 mg/kg level for PCB levels in the waste is based on the assumption that the only way PCB's enter a grazing animal is through the adherence of waste material to the vegetation eaten. EPA recognizes that a certain amount of PCB's may enter the animal due to direct ingestion of soil. At this time, however, EPA does not have sufficient data to know how that factor should be used in the analysis. Moreover, the recommendations from FDA did not take that factor into consideration.

As discussed earlier this portion of the regulation is being issued as "interim final", which means that further public comment is solicited. EPA encourages the public to provide suggestions and data that would help the Agency to account for the direct ingestion of soil in setting a PCB standard.

I. Disease (Section 257.3–6)

Solid wastes can contain pathogenic bacteria, viruses and parasites which can infect both humans and animals. Wastes can provide food and harborage for rodents and flies which are capable of transmitting these disease organisms to humans and animals. Other routes of disease transmission to humans and animals include direct contact with wastes during landspreading operations, contact with soil or plants which have been contaminated with wastes, or ingestion of food and water contaminated with wastes.

The proposed criteria required protection of public health by control of disease vectors. This requirement was to be met through minimizing the availability of food and harborage for disease vectors or through other techniques where appropriate. In another section, the proposed criteria required stabilization of solid waste of concern due to its pathogen content when applied directly to the surface of land used for the production of food-chain crops. In addition, a one-year waiting period was prescribed before growing human food crops which are normally eaten raw. In yet another section, the proposed criteria required controlled access to solid waste disposal facilities so as to minimize exposure of the public to exposed waste.

The final disease criterion combines provisions concerning vectors and pathogens. The provision concerning vectors calls for the minimization of on-site populations of disease vectors. Periodic application of cover material (usually at the end of each operating day) or other appropriate techniques should satisfy the performance standard.

Sewage sludge and septic tank pumpings are the solid wastes which are generally applied to the surface of the land and are of concern due to their pathogen content. To protect public health, the criteria provide for control of pathogens in disposal of these wastes by one of several operational approaches as described below.

Sewage sludge applied to the land surface or incorporated into the soil must be treated by a Process to Significantly Reduce Pathogens. Aerobic digestion, air drying, anaerobic digestion, composting, lime stabilization, or other similar techniques will satisfy this requirement. In addition, public access to the site must be controlled for at least 12 months, and grazing by animals whose products are consumed by humans must be prevented for at least one month.

Septic tank pumpings must be treated by one of the Processes to Significantly Reduce Pathogens, unless public access to the facility is controlled for at least 12 months and grazing by animals whose products are consumed by humans is prevented for at least one month. Neither set of provisions for sewage sludge or septic tank pumpings apply where these wastes are disposed of by a trenching or burial operation.

Further public health protection is required when sewage sludge or septic tank pumpings are applied to land where crops for direct human consumption are grown less than 18 months after waste application. In these instances, the waste material must be treated, prior to application, by a Process to Further Reduce Pathogens. Beta ray irradiation, gamma ray irradiation, pasteurization or other equivalent methods will satisfy this requirement if performed after a Process to Significantly Reduce Pathogens. High-temperature composting, heat drying, heat treatment and thermophilic aerobic digestion will satisfy this requirement without prior treatment. A Process to Further Reduce Pathogens is not required if there is no contact between the solid waste and the edible portion of the crop, as long as the solid waste is treated by a Process to Signficantly Reduce Pathogens prior to application. In addition, public access to the facility must be controlled for at least 12 months after solid waste application, and grazing of animals whose products are consumed by humans must be prevented for at least one month.

Like the portion of the criteria concerning application of solid waste to food-chain crops (§ 257.3–4), the sewage sludge and septic tank pumpings provisions of the disease section are being issued as an "interim final" regulation. While there was extensive public review and comment on the proposed regulation, the public has not had a full opportunity to examine and analyze the new data and technical support for this section. At the same time EPA believes that it must promulgate this portion of the regulation in order to satisfy the spirit of the court order mandating issuance of the criteria. EPA will fully review all comments and make changes in the regulation if such modifications are warranted by the data.

(1) *Disease Vectors.* Some commenters sought a more specific statement of the performance objective of this provision. EPA explored the possibility of developing a numerical performance objective, but determined that such a standard would not be meaningful. While the risk from disease vectors is very real, the risk cannot be translated into a measure of "rats per square meter" or "flies per cubic foot of air space." Moreover, such performance

standards could not be measured with any accuracy. Therefore, EPA made the standard more specific by requiring minimization of on-site populations of disease vectors. This statement of the standard leaves no question that the facility must not be a breeding ground, habitat or feeding area for vector populations. At the same time, it provides some flexibility in the implementation of the standard.

Several commenters indicated that, since there are a number of techniques to protect public health from disease vectors, the phrase "minimizing the availability of food and harborage for vectors through periodic application of cover material" should be deleted. EPA agrees and has done so.

At most facilities which dispose of putrescible wastes, the most effective means to control rodents is the application of cover material at the end of each operating day. Other means include composting or processing the waste, so as to render it unattractive to rodents, or using rodenticides. At some facilities, disease vectors such as flies may be more difficult to control than rodents; but certain practices, such as the periodic application of cover material, can help alleviate the problems. Mosquitoes can be controlled by eliminating stagnant water for breeding, by predatory or reproductive control and, if necessary, by spraying with insecticides or repellants.

Cover material also serves other purposes: (a) It helps contain odor, litter, and air emissions, thereby improving the facility's aesthetic quality; (b) it reduces the potential for fires; (c) it reduces rainwater infiltration, thereby decreasing leachate generation and surface and ground-water contamination; and (d) it improves the facility's appearance and enhances utilization after completion.

Since periodic application of cover material is an effective, widely used and generally preferred means of controlling vectors, EPA believes that it is appropriate to specify it in the criteria. It is impractical, however, to cover some wastes. Moreover, cover material is not generally necessary for wastes which are non-putrescible, relatively stable or inert. The criteria allow for other techniques to be employed in these situations.

EPA has not included the phrase "minimizing the availability of food and harborage" in the final standard. That language would not cover such control measures as repellants, insecticides and rodenticides, which could be effective in meeting the objective of this section.

Commenters also requested a definition of the term "disease vector." Disease vectors are rodents, flies and mosquitoes, since these are the known organisms common at disposal facilities that are capable of transmitting disease.

(2) *Sewage Sludge and Septic Tank Pumpings.* In establishing regulations to protect public health from pathogen-induced disease, it must be recognized that there is a distinction between being exposed to disease-producung organisms and actually acquiring a disease. Healthy humans and animals can tolerate small numbers of pathogenic organisms without acquiring a disease. Disease normally occurs when the body's immune system is impaired, or the dose of pathogens is so great that it overwhelms the body's defense mechanism. In setting these criteria, the goal is to prevent human exposure to large numbers of pathogenic organisms due to solid waste disposal activities.

Commenters requested specification of which solid wastes are of concern due to their pathogen content. The criteria have been modified to specify sewage sludge and septic tank pumpings as the wastes which are generally applied to the surface of the land and are of concern due to their pathogen content. Although little information is available on septic tank pumpings, the relatively long residence time of the bulk of the waste material in a septic tank should reduce the density of pathogenic organisms. Therefore, the Agency has tentatively concluded that septic tank pumpings have the same general characteristics with regard to land application as partially treated municipal sewage sludge. The public is invited to submit pertinent data on this subject; the Agency will review any new information and reassess these regulations accordingly.

Sewage sludge and septic tank pumpings contain various types of pathogenic bacteria, viruses and parasites. While bacteria are greatly reduced by sunlight and drying, viruses may persist in soils and on vegetation for several weeks or months. Parasitic ova and cysts are quite resistant to disinfectants and adverse environmental conditions. Many, in fact, require a period of free-living existence in the soil before becoming infectious to man. Therefore, a major reason for requiring the control of pathogens is the potential for human ingestion of soil or plants contaminated with such wastes containing ova or cysts.

Some commenters suggested that the criteria require a "pathogen-free" sewage sludge. EPA does not believe that such regulation is necessary to avoid a reasonable probability of adverse effects on the population that may come in contact with sludge-amended fields. A greater degree of protection is needed for certain solid waste disposal practices (i.e., application to land where food-chain crops are grown), and this section provides for such protection.

The proposed regulation relied on stabilization as the principal treatment technique to reduce the risk of pathogen-induced disease. However, because the term "stabilization" conventionally related to odor control and to a lesser degree pathogen reduction, this term is no longer used in the criteria. The criteria have been revised to require that sewage sludge and, under certain conditions, septic tank pumpings be treated by a Process to Significantly Reduce Pathogens. These processes include aerobic digestion, air drying, anaerobic digestion, composting (three techniques), lime stabilization or other equivalent techniques.

EPA recognizes that not all of these processes achieve exactly the same level of pathogen reduction. Variations in weather, residence times, temperatures and other factors will influence the effectiveness of each process. The Agency also recognizes that different processes may be more or less effective in destroying certain types of pathogens (i.e., bacteria, viruses or parasites). Each process, however, has been shown to achieve a significant reduction in pathogen levels. Therefore, EPA believes that they are appropriate to achieve the objectives of this section.

The proposed regulation required controlled access to disposal facilities so as to minimize exposure of the public to hazards posed by exposed waste. The final regulation seeks to minimize exposure of the public to pathogens in the upper layers of waste-amended soils. Since pathogens in the surface soil are generally reduced to insignificant levels within 12 months of application, the criteria require that public access to the facility be controlled for that period of time. "Controlled" does not mean that all entry on the site be precluded. The term "controlled," rather than "prevented," was chosen for regulating public access, because with proper precautions there appears to be no health hazard. However, there would be a health hazard if, for example, children were permitted to play on the waste-amended soil. Therefore, fencing would be necessary if these wastes were applied to areas frequented by the general public (e.g., park lands) but fencing would not be necessary on farm land which was not available for use by the public.

This section also includes a limit on animal access to the fields for grazing for one month after sewage sludge is applied. This is appropriate for several reasons. First, the animal acts as a first line of defense against human contact with pathogens. The products derived from the animal (meat or milk) will not contain the same level of pathogens as might enter the animal due to grazing on waste-amended fields. Second, in many cases rainfall in the one-month period after application will wash the sludge off the crop. Third, available evidence indicates that where sludge does remain on the crop, a one-month period should be sufficient for natural weather conditions (e.g., sunshine, wind) to destroy most pathogenic organisms.

The access restrictions described above are required for all facilities receiving sewage sludge, even after the waste has been treated by a Process to Significantly Reduce Pathogens. For septic tank pumpings, the access restrictions may be used as an alternative to such a Process. This is due to the fact that containment in a septic tank will result in partial pathogen reduction in the waste and should diminish its attractant potential to disease vectors such as flies and mosquitoes. However, septic tank pumpings do not undergo the kind of pathogen destruction that can occur with anaerobic digestion, because the waste is being continually reinoculated with fresh waste material. Therefore, EPA concluded that such wastes should be treated with a Process to Significantly Reduce Pathogens or be subject to the access restrictions.

As indicated earlier, special treatment is necessary for food-chain crop cultivation, where the risk of direct human consumption of crops contaminated by pathogens is higher. To provide protection, the proposed regulation relied on a one-year waiting period between waste application and use of that land for food-chain crops. The regulation now calls for the use of a Process to Further Reduce Pathogens if crops for direct human consumption are grown within 18 months of application or incorporation of the sewage sludge or septic tank pumpings. If no such crops are grown within 18 months of application, treatment by a Process to Further Reduce Pathogens is not required.

The processes chosen should essentially destroy all bacteria and viruses and greatly reduce the number of parasites in the waste material. Two sets of processes are permitted—those which are sufficient in themselves and those which must follow a Process to Significantly Reduce Pathogens in order to be effective. Processes which are adequate in themselves are high-temperature composting, heat drying, heat treatment and theromophilic aerobic digestion. Processes which must follow a Process to Significantly Reduce Pathogens are beta ray irradiation, gamma ray irradiation and pasteurization. This sequence of processes is necessary to assure that the waste is not an attractant to vectors. Irradiation or pasteurization, while effective against pathogens, do not provide the volatile solids reduction necessary to prevent a vector problem.

Based on available data, the Agency concluded that a Process to Further Reduce Pathogens is not necessary when there is an 18-month interval between land application of solid waste and the growing of crops for direct human consumption. EPA recognizes that there is some uncertainty about the life expectancy of pathogens in wastes applied to croplands. Bacteria and viruses persist for only a few months, but parasites, particularly resistant species such as *Ascaris lumbricoides*, may last much longer. Reports range from "no survivors" after a few months to "some survivors" (not necessarily viable) after ten years for such organisms.

Survival is most likely in the soil below the top five centimeters of soil. Field conditions such as sunlight, desiccation, freezing, heat and freeze-thaw cycles are effective at reducing survival times in the upper layer of the soil. EPA selected the 18-month period because within that period most of the waste-amended soil will be exposed to the hostile environment found at the soil surface. Agricultural soils are typically plowed or cultivated at least annually. Thus, an 18-month waiting period assures that soil which was previously below the surface will be exposed to the harsh surface conditions for at least six months before planting. The growing period will provide additional exposure of the pathogens before harvest. EPA believes that this will provide a reasonable probability that pathogen levels will be greatly reduced. Since this is an "interim final" regulation, EPA encourages public comment on the appropriateness of this rationale.

EPA recognizes that for some crops (e.g., citrus fruits, corn) the edible portions are not exposed to, nor are likely to come in contact with, the sewage sludge or septic tank pumpings. Therefore, there is no need to use a Process to Further Reduce Pathogens when such a crop is grown. However, in this case the waste must be treated by a Process to Significantly Reduce Pathogens, public access to the facility must be controlled for at least 12 months, and the grazing of animals prevented for at least one month after application of the waste. The Agency chose the more conservative approach of requiring significant pathogen reduction and controlled access for both sewage sludge and septic tank pumpings because even where direct contact appears unlikely, the quality of crops which are directly consumed by man must be assured.

In examining the health risk presented by pathogens, EPA determined that pathogens are not likely to migrate in the soil. Pathogens tend to remain intimately associated with the waste material and are often too large to move through soil pore systems. Also, soils have been reported to be effective in removing viruses and bacteria from water. Surface erosion with the resultant water runoff seems to be the only route for movement of pathogens. Based on these findings, the Agency concluded that sewage sludge and septic tank pumpings that are placed underground by a trenching or burial operation should not be subject to this section. Under such circumstances there will be minimal movement of the organisms through the soil, and the risk of erosion is slight because the wastes are completely covered.

J. Air (Section 257.3–7)

Open burning is the uncontrolled or unconfined combustion of solid wastes. Open burning is a potential health hazard, can cause property damages, and can be a threat to public safety. Smoke from open burning can reduce aircraft and automobile visibility and has been linked to automobile accidents and death on expressways. The air emissions associated with open burning are much higher than those associated with incinerators equipped with air pollution control devices.

The proposed criteria provided for control of air emissions through three stipulations: First, the facility was to control air emissions so as to comply with Federal, State, and local air regulations. Second, all open burning of residential, commercial, institutional, and industrial solid wastes was prohibited. Third, open burning of other solid wastes could be permitted if in compliance with State and local air regulations.

This final air criterion has two components. First, there shall be no open burning of residential, commercial, institutional or industrial solid waste. (This provision does not apply to infrequent burning of agricultural wastes, silvicultural wastes, land-clearing debris, diseased trees, debris from emergency clean-up operations and ordnance.) Second, air emissions caused by solid waste disposal activities shall not violate applicable requirements developed for State implementation plans (SIP's) under Section 110 of the Clean Air Act.

While several commenters suggested that a ban on open burning is unnecessary, EPA has decided to retain that provision for residential, commercial, institutional or industrial waste. The ongoing open burning of these wastes presents significant hazards to human health, and no health or environmental benefit is derived from the practice. Several commenters suggested allowing open burning with a variance. There is no environmental rationale for such a variance because open burning does not lessen the need for disease vector control or leachate control for maintaining surface and ground-water quality. Moreover, variance procedures for this situation would be particularly difficult to administer because of the dynamic nature of the many variables involved (existing air quality, wind speed, humidity, mixing and vertical dispersion, efficiency of the burn, amount and type of waste, etc.).

EPA decided to exempt from the open burning prohibition those wastes which are typically burned infrequently. The burning of agricultural wastes in the field, land-clearing debris, standing trees in a forest, diseased trees, debris from emergency clean-up operations and ordnance is not typically an ongoing practice and, thus, does not present a significant environmental risk. In addition some of these practices, particularly the destruction of disease-carrying trees or debris from emergency clean-up operations, provides an added environmental benefit in preventing chances of disease or accident. It should be noted, however, that the criteria assure that the conduct of these infrequent acts of burning must be in compliance with applicable requirements developed under the State SIP.

In requiring compliance with the SIP, EPA is seeking to coordinate the criteria with the Clean Air Act, as mandated in Section 1006 of the Act. The regional health concerns addressed through the SIP's are clearly of concern under the Act as well. The prohibition of open burning should prevent most air quality problems. Where such concerns are not covered by the open burning ban, EPA believes that it is unacceptable for solid waste disposal activities to cause violations of SIP requirements.

EPA has eliminated that part of the proposed regulation that required compliance with "all applicable Federal, State and local air regulations" and the reference to protection of public health and welfare. Some commenters said that the proposed criteria "federalized" State and local air regulations. EPA is not federalizing any such regulations in the final criteria. In tying the criteria to the SIP's, EPA is assuring that, at a minimum, solid waste activities that undermine Congressionally-established Federal environmental air quality objectives will not be considered adequate under the Act.

Several commenters requested clarification regarding the impact of the criteria on the use of pit or trench incinerators. Emission factors (i.e., particulates) for such incinerators equal or exceed those for open burning dumps. Since such devices do not control emissions, they fit the definition of open burning. Thus, for purposes of the criteria, combustion in a trench incinerator constitutes "open dumping."

Comments were requested in the Preamble of the proposed regulation on the advisability of including in the final promulgation specific air quality limits which would be based on Occupational Safety and Health Administration (OSHA) air quality standards. Several commenters noted that since OSHA air quality standards are based on workplace exposure and not ambient air quality, the inclusion of these standards would be inappropriate and possibly confusing. Air quality standards based on OSHA regulations have not been included in the final promulgation.

Commenters also suggested that the content of the air criteria be moved to the safety criteria (§ 257.3–8) since many of the dangers of open burning relate directly to public safety. The Agency considers the problems of open burning to be broader than just public safety; thus, this change was not made. However, the safety criteria have been revised to reference the air criteria.

K. Safety (Section 257.3–8)

This portion of the criteria addresses a set of adverse effects involving potential accidents which could be caused by solid waste disposal activities. The legislative history of the Act indicates that in passing the provisions authorizing these criteria the Congress was concerned about all of the effects addressed in this section. The safety hazards addressed in the final regulation include explosive gases, fires, bird hazards to aircraft and public exposure to wastes due to uncontrolled access to disposal sites.

The proposed regulation also contained a provision for toxic and asphyxiating gases. While EPA is quite concerned about the emission of such gases from solid waste, EPA was unable to identify sufficient information on the nature of this problem to support the setting of particular standards. The existing data on the generation of toxic and asphyxiating gases in solid waste is quite limited. In particular, it is difficult to define a set of gases generated in solid waste disposal that present a public health hazard. Even if such a set of gases could be identified it is difficult to determine, on the basis of data currently available to EPA, what levels of such gases may be tolerated without a substantial risk to public health or the environment. EPA will continue to explore this problem. However, at present there is insufficient information to support particular limits on toxic and asphyxiating gases.

(1) *Explosive gases.* Solid waste disposal activities may produce explosive gases. In particular, methane gas is a product of solid waste decomposition. The accumulation of a sufficient concentration of methane gas in disposal facility structures or nearby off-site structures may pose a serious threat to the health and welfare of facility employees, users of the disposal site, and occupants of nearby structures. Explosions resulting in injury and death have been caused by gases from solid waste disposal.

The proposed criteria required that the concentration of explosive gases in facility structures and in soil at the facility property boundary not reach the lower explosive limits (LEL) for the gases. The final regulation is essentially the same except that concentrations in facility structures will not be allowed to exceed 25 percent of the lower explosive limit for the gas. In addition the final standard, which could potentially be applicable to several explosive gases, will only be concerned with methane at this time.

Commenters suggested that the gas criteria be deleted and that control be left to the Occupational Safety and Health Administration (OSHA). Following consultation with OSHA, the Agency rejected this suggestion because the jurisdiction of OSHA does not include all solid waste disposal facilities and practices of concern to the Act, nor does it include off-site residences to which gases can migrate.

The Agency has decided to adjust the standard for facility structures to provide a margin of safety. Several commenters suggested such a change, since allowing explosive gas to accumulate in concentrations just under the lower explosive limit would be extremely dangerous and would not provide for a reasonable probability of avoiding adverse effects. In selecting the 25% figure EPA is using a safety factor recognized by other Federal agencies as being appropriate for similar situations.

EPA also concluded that such a safety factor was unnecessary at the property boundary. Gases at or below the LEL at the property boundary will necessarily become somewhat diffused before passing into a structure beyond the property boundary. Thus, in assuring that the LEL is not exceeded at the boundary EPA has provided a margin of safety against an off-site explosion.

EPA has selected methane as the single gas of concern. The information available to EPA indicates that build up of methane gas has been the principal source of explosions associated with solid waste disposal. Other gases may be added to the list as new information develops.

Commenters recommended that disposal facilities not in close proximity to off-site structures be exempted from the gas criteria. Considering that gas production in disposal facilities is a long-term process continuing for decades, the Agency rejected this recommendation. Facilities which are remote today may be surrounded by extensive development in the future, especially after completion of disposal operations.

(2) *Fires.* Fires at solid waste disposal facilities pose the threat of property damage and injury or death to facility employees, users, and nearby residents. Examples of circumstances which can lead to fires associated with disposal facilities or practices are: Vandalism, carelessness, spontaneous combustion, open burning of wastes, and disposal of hot ashes.

The proposed criteria required that all fires be extinguished expeditiously and that fire hazards be minimized through proper site construction and design and periodic application of cover material where appropriate.

According to the final regulation, the facility or practice shall not pose a hazard to the safety of persons or property from fires. This objective can be served by compliance with the air criterion (§ 257.3-7), particularly the open burning ban, and through periodic application of cover material.

Commenters objected to the vague nature of this provision as originally proposed. While some level of flexibility is necessary, EPA has tried to make this standard as specific as possible. The reference to "expeditious" extinguishing of fires was eliminated. EPA also specified types of operational practices to accomplish the goals of this section.

Commenters suggested that, due to the relationship between open burning and potential fire hazards, the prohibition on open burning be incorporated into this section. As explained previously the safety criteria now reference the air criterion (which contains the prohibition of open burning.)

(3) *Bird Hazards.* Many reports and investigations show that disposal facilities and practices involving putrescible wastes often attract birds, in spite of vector control efforts (compaction and cover of wastes, etc.). When solid wastes are disposed in the vicinity of airports, the birds attracted to the area can present a significant risk of accidents due to collisions between birds and planes. The Federal Aviation Administration (FAA) has issued FAA Order 5200.5, "FAA Guidance Concerning Sanitary Landfills on or Near Airports" (October 16, 1974). The order states that solid waste disposal facilities have been found by study and observation to be artificial attractants of birds and, therefore, "may be incompatible with safe flight operations" when located in the vicinity of an airport.

The proposed criteria required that disposal facilities not be located within the two distance limits (10,000 feet for turbojets and 5,000 feet for piston-type aircraft) specified in FAA Order 5200.5 unless the facility was found to not pose a bird hazard to aircraft. For facilities beyond the specified distances, but within the conical surface described by FAA Regulations (FAR), Part 77, facilities were to be reviewed on a case-by-case basis for a potential bird hazard.

The final regulation retains the basic approach but clarifies several terms, including "airport" and "bird hazard." The provision for case-by-case analysis of facilities within the conical surface has been dropped.

Some commenters questioned whether the Act provides authority to control solid waste disposal on the basis of bird hazards to aircraft. They claimed that the FAA has adequate authority to prevent bird hazards to aircraft, concluding that this section of the criteria is not necessary.

The criteria are required to address the prevention of adverse effects on health and the environment from solid waste disposal facilities. The legislative history (H.R. Rep. No. 94-1491) cites an aircraft crash resulting from birds attracted to a disposal facility as one example of adverse effects of open dumps. There are also many other examples of such hazards from disposal facilities. Therefore, the Agency has concluded that this issue is clearly within the scope of this regulation.

Although the FAA is authorized to control airport operations to reduce bird hazards to aircraft, its authority does not extend to disposal facilities outside airport boundaries which may pose such hazards. It should be noted, however, that EPA is not "enforcing" the FAA order. The selection of the distances specified in that order is merely a recognition that they represent a reasonable determination of the danger zone around an airport. Likewise, it should be made clear that neither this regulation nor the proposed standard prohibited the disposal of solid waste within the specified distances. Instead, the distances define a "danger zone" within which particular care must be taken to assure that no bird hazard arises.

Some commenters challenged the relevancy of the 10,000 foot (for turbojets) and 5,000 foot (for piston-type aircraft) distances for defining the danger zone for bird/aircraft collisions. The distances cited were derived from FAA Order 5200.5. The distances are based on the consideration that over 62 percent of all bird strikes occur below altitudes of 500 feet (150 meters), and that aircraft are generally below this altitude within the distances specified.

Some commenters emphasized that bird strikes do occur outside the distances established in the regulation. Consultation with FAA personnel and other experts in the field of bird/aircraft hazards has revealed that, even when disposal facilities are located beyond the distances specified, hazards can exist where an airport is situated between a disposal facility and bird feeding, roosting, or watering sites. The hazard arises as birds traverse the airport in flying between the disposal facility and watering, feeding or roosting areas. However, EPA does not have sufficient information to indicate how serious this problem is. Moreover, the available data is insufficient to support the setting of national regulations to cover such contingencies. At some point it becomes difficult to isolate the independent effect of solid waste disposal activities on the bird hazard problem.

EPA has also decided to give a clearer definition of some key terms. The definition of "Airport" includes those airfields currently defined by the FAA as public-use airports. The regulation applies to that set of airports because existing data indicates that the preponderance of bird strikes occur at public-use airports. For example, 120 of the 121 airports reporting strikes in 1977 were public-use airports, and 220 of the 223 airports reporting strikes in 1978 were public-use airports. The FAA agrees with this approach. EPA, in consultation with the FAA, may broaden the class of airports of concern if it receives information demonstrating that a similar bird hazard exists at other fields.

In defining the airports of concern EPA has also eliminated the proposed criteria's reference to "runways planned to be used." As several commenters pointed out, such a reference would not be workable because it would require speculation about future siting of airports.

EPA also makes it clear that the "bird hazard" of concern is "an increase in the likelihood of bird/aircraft collisions." Solid waste disposal within the danger zone may continue as long as it can be shown that the operation can be managed in such a way as to not increase the risk of collision within the specified distances.

After considering public comments, EPA has deleted portions of the proposed standard. Several commenters stated that the use of the conical surface in the criteria was ambiguous and not applicable to this standard. The conical surface is an imaginary plane delineating an airspace segment 150 feet above the established airport elevation. The FAA prohibits stationary objects in this space because they might interfere with approaching and departing aircraft. This is inapplicable to solid waste disposal activities for two reasons: (1) Birds, the "obstructions" of concern in this regulation, are hardly stationary; and (2) solid waste disposal activities are typically low-profile operations (below 150 feet) and are not likely to constitute obstructions into the conical surface.

Commenters asked who was responsible for determining whether a facility posed a bird hazard to aircraft. The Act and the CWA create the implementing mechanisms for these criteria. However, in this instance consultation with the FAA and the Fish and Wildlife Service would be very helpful. Furthermore, actions at *both* the airport and the disposal facility can reduce or eliminate hazards. Therefore, where appropriate this determination should be made in consultation with these agencies, as well as with the owners and operators of the airport of concern.

(4) *Access.* Materials and activities associated with solid waste disposal facilities can cause injury or death to persons at the facilities. Potential causes of such harm include:

(a) Operation of heavy equipment and haul vehicles;

(b) Hazards associated with the types of waste, including sharp objects, pathogens, and toxic, explosive, or flammable materials; and

(c) Accidental or intentional fires.

The proposed criteria required that entry to the facility be controlled in order to minimize exposure of the public to hazards of heavy equipment operation and exposed waste.

The final criteria call for control of access to protect the public from on-site exposure to health and safety hazards.

The importance of access control cannot be overstated, since persons have suffered injury and even death at uncontrolled waste disposal facilities. Furthermore, in most cases, there is little economic impact on solid waste disposal operations in accomplishing such control.

During normal operating hours, proper management controls can minimize safety hazards. For example, potential harm to facility operating personnel can be reduced through proper training, use of safety equipment, control of waste types, and other practices. The most effective means of minimizing the risk of injury to other persons is by complete prohibition of access to the site by non-users (e.g. by suitable fencing) and strict control of users while on the site. For individuals disposing of small amounts of wastes, storage or special disposal facilities can be provided at the entrance to the facility or away from the area being utilized by professional solid waste management personnel.

The principal change from the proposed regulation is the broadening of the regulation's coverage. Accidents at solid waste disposal sites are not limited to hazards caused by heavy equipment operation and exposed waste. EPA believes that particular types of hazards should not be specified in the regulation, thereby allowing for flexibility in how the standard is applied. Therefore, the criteria seek to avoid public exposure to all potential health and safety hazards at solid waste disposal sites.

Two commenters stated that the proposed requirement for fencing was unreasonable. It should be noted that the Agency did not propose a requirement for fencing. At many facilities natural barriers exist which make public access very difficult; however, even if the criteria were complied with through the installation of a fence around the entire property the cost would be relatively insignificant when compared to the other costs required to properly operate a disposal facility.

V. Environmental and Economic Impacts

Voluntary environmental and economic impact analyses onthis regulation have been performed and are presented in the "Final Environmental Impact Statement on the Criteria for Classification of Solid Waste Disposal Facilities". These analyses are not required by the National Environmental Policy Act but provide information pertinent to the development and use of this regulation. Copies of this two-volume report may be obtained on request from: Solid Waste Information, U.S. EPA, 26 West St. Clair, Cincinnati, Ohio 45268.

EPA has also prepared a number of background documents that respond to public comments not addressed in the Preamble. These documents may be examined at E.P.A., 401 M Street, S.W., Washington, D.C. 20460 in room 2632. If there are apparent inconsistencies between these documents and this Preamble, the latter shall represent the Agency's position.

Dated: September 10, 1979.

Douglas M. Costle,
Administrator.

Title 40 CFR is amended by adding a new Part 257 to read as follows:

PART 257—CRITERIA FOR CLASSIFICATION OF SOLID WASTE DISPOSAL FACILITIES AND PRACTICES

Sec.
257.1 Scope and purpose.
257.2 Definitions.
257.3 Criteria for classification of solid waste disposal facilities and practices.
257.3–1 Floodplains.
257.3–2 Endangered species.
257.3–3 Surface water.
257.3–4 Ground water.
257.3–5 Application to land used for the production of food-chain crops. (Interim final).
257.3–6 Disease.
257.3–7 Air.
257.3–8 Safety.
257.4 Effective date.

Authority: Sec. 1008(a)(3), and sec. 4004(a), Pub. L. 94–580, 90 Stat. 2803 and 2815 (42 U.S.C. 6907(a)(3), 6944); sec. 405(d), Pub. L. 95–217, 91 Stat. 1591, 1606 (33 U.S.C. 1345).

§ 257.1 Scope and purpose.

(a) These criteria are for use under the Resource Conservation and Recovery Act (the Act) in determining which solid waste disposal facilities and practices pose a reasonable probability of adverse effects on health or the environment.

(1) Facilities failing to satisfy these criteria will be considered open dumps for purposes of State solid waste management planning under the Act.

(2) Practices failing to satisfy these criteria constitute open dumping, which is prohibited under Section 4005 of the Act.

(b) These criteria also provide guidelines for sludge utilization and disposal under Section 405(d) of the Clean Water Act, as amended. To comply with Section 405(e) the owner or operator of any publicly owned treatment works must not violate these criteria in the disposal of sludge on the land.

(c) These criteria apply to all solid waste disposal facilities and practices with the following exceptions:

(1) The criteria do not apply to agricultural wastes, including manures and crop residues, returned to the soil as fertilizers or soil conditioners.

(2) The criteria do not apply to overburden resulting from mining operations intended for return to the mine site.

(3) The criteria do not apply to the land application of domestic sewage or treated domestic sewage. The criteria do apply to disposal of sludges generated by treatment of domestic sewage.

(4) The criteria do not apply to the location and operation of septic tanks. The criteria do, however, apply to the disposal of septic tank pumpings.

(5) The criteria do not apply to solid or dissolved materials in irrigation return flows.

(6) The criteria do not apply to industrial discharges which are point sources subject to permits under Section 402 of the Clean Water Act, as amended.

(7) The criteria do not apply to source, special nuclear or byproduct material as defined by the Atomic Energy Act, as amended (68 Stat. 923).

(8) The criteria do not apply to hazardous waste disposal facilities which are subject to regulation under Subtitle C of the Act.

(9) The criteria do not apply to disposal of solid waste by underground well injection subject to the regulations (40 CFR Part 146) for the Underground Injection Control Program (UICP) under the Safe Drinking Water Act, as amended, 42 U.S.C. 3007 et seq.

§ 257.2 Definitions.

The definitions set forth in Section 1004 of the Act apply to this Part. Special definitions of general concern to this Part are provided below, and definitions especially pertinent to particular sections of this Part are provided in those sections.

"Disposal" means the discharge, deposit, injection, dumping, spilling, leaking, or placing of any solid waste or hazardous waste into or on any land or water so that such solid waste or hazardous waste or any constituent thereof may enter the environment or be emitted into the air or discharged into any waters, including ground waters.

"Facility" means any land and appurtenances thereto used for the disposal of solid wastes.

"Leachate" means liquid that has passed through or emerged from solid waste and contains soluble, suspended or miscible materials removed from such wastes.

"Open dump" means a facility for the disposal of solid waste which does not comply with this part.

"Practice" means the act of disposal of solid waste.

"Sanitary landfill" means a facility for the disposal of solid waste which complies with this part.

"Sludge" means any solid, semisolid, or liquid waste generated from a municipal, commercial, or industrial wastewater treatment plant, water supply treatment plant, or air pollution control facility or any other such waste having similar characteristics and effect.

"Solid waste" means any garbage, refuse, sludge from a waste treatment plant, water supply treatment plant, or air pollution control facility and other discarded material, including solid, liquid, semisolid, or contained gaseous material resulting from industrial, commercial, mining, and agricultural operations, and from community activities, but does not include solid or dissolved materials in irrigation return flows or industrial discharges which are point sources subject to permits under Section 402 of the Federal Water Pollution Control Act, as amended (86 Stat. 880), or source, special nuclear, or byproduct material as defined by the Atomic Energy Act of 1954, as amended (68 Stat. 923).

"State" means any of the several States, the District of Columbia, the Commonwealth of Puerto Rico, the Virgin Islands, Guam, American Samoa, and the Commonwealth of the Northern Mariana Islands.

§ 257.3 Criteria for classification of solid waste disposal facilities and practices.

Solid waste disposal facilities or practices which violate any of the following criteria pose a reasonable probability of adverse effects on health or the environment:

§ 257.3–1 Floodplains.

(a) Facilities or practices in floodplains shall not restrict the flow of the base flood, reduce the temporary water storage capacity of the floodplain, or result in washout of solid waste, so as to pose a hazard to human life, wildlife, or land or water resources.

(b) As used in this section:

(1) "Based flood" means a flood that has a 1 percent or greater chance of recurring in any year or a flood of a magnitude equalled or exceeded once in 100 years on the average over a significantly long period.

(2) "Floodplain" means the lowland and relatively flat areas adjoining inland and coastal waters, including flood-prone areas of offshore islands, which are inundated by the base flood.

(3) "Washout" means the carrying away of solid waste by waters of the base flood.

§ 257.3–2 Endangered species.

(a) Facilities or practices shall not cause or contribute to the taking of any endangered or threatened species of plants, fish, or wildlife.

(b) The facility or practice shall not result in the destruction or adverse modification of the critical habitat of endangered or threatened species as identified in 50 CFR Part 17.

(c) As used in this section:

(1) "Endangered or threatened species" means any species listed as such pursuant to Section 4 of the Endangered Species Act.

(2) "Destruction or adverse modification" means a direct or indirect alteration of critical habitat which appreciably diminishes the likelihood of the survival and recovery of threatened or endangered species using that habitat.

(3) "Taking" means harassing, harming, pursuing, hunting, wounding, killing, trapping, capturing, or collecting or attempting to engage in such conduct.

§ 257.3–3 Surface Water.

(a) A facility or practice shall not cause a discharge of pollutants into waters of the United States that is in violation of the requirements of the National Pollutant Discharge Elimination System (NPDES) under Section 402 of the Clean Water Act, as amended.

(b) A facility or practice shall not cause a discharge of dredged material or fill material to waters of the United States that is in violation of the requirements under Section 404 of the Clean Water Act, as amended.

(c) A facility or practice shall not cause non-point source pollution of waters of the United States that violates applicable legal requirements implementing an areawide or Statewide water quality management plan that has been approved by the Administrator under Section 208 of the Clean Water Act, as amended.

(d) Definitions of the terms "Discharge of dredged material", "Point source", "Pollutant", "Waters of the United States", and "Wetlands" can be found in the Clean Water Act, as amended, 33 U.S.C. 1251 et seq., and implementing regulations, specifically 33 CFR Part 323 (42 FR 37122, July 19, 1977).

§ 257.3-4 Ground Water.

(a) A facility or practice shall not contaminate an underground drinking water source beyond the solid waste boundary or beyond an alternative boundary specified in accordance with paragraph (b) of this section.

(b) Only a State with a solid waste management plan approved by the Administrator pursuant to Section 4007 of the Act may establish an alternative boundary to be used in lieu of the solid waste boundary. A State may specify such a boundary only if it finds that such a change would not result in contamination of ground water which may be needed or used for human consumption. This finding shall be based on analysis and consideration of all of the following factors:

(1) The hydrogeological characteristics of the facility and surrounding land;

(2) The volume and physical and chemical characteristics of the leachate;

(3) The quantity, quality, and directions of flow of ground water;

(4) The proximity and withdrawal rates of ground-water users;

(5) The availability of alternative drinking water supplies;

(6) The existing quality of the ground water including other sources of contamination and their cumulative impacts on the ground water; and

(7) Public health, safety, and welfare effects.

(c) As used in this section:

(1) "Aquifer" means a geologic formation, group of formations, or portion of a formation capable of yielding usable quantities of ground water to wells or springs.

(2) "Contaminate" means introduce a substance that would cause:

(i) The concentration of that substance in the ground water to exceed the maximum contaminant level specified in Appendix I, or

(ii) An increase in the concentration of that substance in the ground water where the existing concentration of that substance exceeds the maximum contaminant level specified in Appendix I.

(3) "Ground water" means water below the land surface in the zone of saturation.

(4) "Underground drinking water source" means:

(i) An aquifer supplying drinking water for human consumption, or

(ii) An aquifer in which the ground water contains less than 10,000 mg/1 total dissolved solids.

(5) "Solid waste boundary" means the outermost perimeter of the solid waste (projected in the horizontal plane) as it would exist at completion of the disposal activity.

§ 257.3-5 Application to land used for the production of food-chain crops (interim final).

(a) *Cadmium.* A facility or practice concerning application of solid waste to within one meter (three feet) of the surface of land used for the production of food-chain crops shall not exist or occur, unless in compliance with all requirements of paragraph (a)(1) (i) through (iii) of this section or all requirements of paragraph (a)(2) (i) through (iv) of this section.

(1)(i) The pH of the solid waste and soil mixture is 6.5 or greater at the time of each solid waste application, except for solid waste containing cadmium at concentrations of 2 mg/kg (dry weight) or less.

(ii) The annual application of cadmium from solid waste does not exceed 0.5 kilograms per hectare (kg/ha) on land used for production of tobacco, leafy vegetables or root crops grown for human consumption. For other food-chain crops, the annual cadmium application rate does not exceed:

Time period	Annual Cd application rate (kg/ha)
Present to June 30, 1984	2.0
July 1, 1984 to Dec. 31, 1986	1.25
Beginning Jan. 1, 1987	0.5

(iii) The cumulative application of cadmium from solid waste does not exceed the levels in either paragraph (a)(1)(iii)(A) of this section or paragraph (a)(1)(iii)(B) of this section.

(A)

Soil cation exchange capacity (meq/100g)	Maximum cumulative application (kg/ha)	
	Background soil pH <6.5	Background soil pH ≥ 6.5
<5	5	5
5-15	5	10
>15	5	20

(B) For soils with a background pH of less than 6.5, the cumulative cadmium application rate does not exceed the levels below: *Provided,* That the pH of the solid waste and soil mixture is adjusted to and maintained at 6.5 or greater whenever food-chain crops are grown.

Soil cation exchange capacity (meq/100g)	Maximum cumulative application (kg/ha)
<5	5
5-15	10
>15	20

(2)(i) The only food-chain crop produced is animal feed.

(ii) The pH of the solid waste and soil mixture is 6.5 or greater at the time of solid waste application or at the time the crop is planted, whichever occurs later, and this pH level is maintained whenever food-chain crops are grown.

(iii) There is a facility operating plan which demonstrates how the animal feed will be distributed to preclude ingestion by humans. The facility operating plan describes the measures to be taken to safeguard against possible health hazards from cadmium entering the food chain, which may result from alternative land uses.

(iv) Future property owners are notified by a stipulation in the land record or property deed which states that the property has received solid waste at high cadmium application rates and that food-chain crops should not be grown, due to a possible health hazard.

(b) *Polychlorinated Biphenyls (PCBs).* Solid waste containing concentrations of PCBs equal to or greater than 10 mg/kg (dry weight) is incorporated into the soil when applied to land used for producing animal feed, including pasture crops for animals raised for milk. Incorporation of the solid waste into the soil is not required if it is assured that the PCB content is less than 0.2 mg/kg (actual weight) in animal feed or less than 1.5 mg/kg (fat basis) in milk.

(c) As used in this section:

(1) "Animal feed" means any crop grown for consumption by animals, such as pasture crops, forage, and grain.

(2) "Background soil pH" means the pH of the soil prior to the addition of substances that alter the hydrogen ion concentration.

(3) "Cation exchange capacity" means the sum of exchangeable cations a soil can absorb expressed in milli-equivalents per 100 grams of soil as determined by sampling the soil to the depth of cultivation or solid waste placement, whichever is greater, and analyzing by the summation method for distinctly acid soils or the sodium acetate method for neutral, calcareous or saline soils ("Methods of Soil Analysis, Agronomy Monograph No. 9." C. A. Black, ed., American Society of Agronomy, Madison, Wisconsin. pp 891–901, 1965).

(4) "Food-chain crops" means tobacco, crops grown for human

consumption, and animal feed for animals whose products are consumed by humans.

(5) "Incorporated into the soil" means the injection of solid waste beneath the surface of the soil or the mixing of solid waste with the surface soil.

(6) "Pasture crops" means crops such as legumes, grasses, grain stubble and stover which are consumed by animals while grazing.

(7) "pH" means the logarithm of the reciprocal of hydrogen ion concentration.

(8) "Root crops" means plants whose edible parts are grown below the surface of the soil.

(9) "Soil pH" is the value obtained by sampling the soil to the depth of cultivation or solid waste placement, whichever is greater, and analyzing by the electrometric method. ("Methods of Soil Analysis, Agronomy Monograph No. 9," C.A. Black, ed., American Society of Agronomy, Madison, Wisconsin, pp. 914–926, 1965.)

§ 257.3-6 Disease.

(a) *Disease Vectors.* The facility or practice shall not exist or occur unless the on-site population of disease vectors is minimized through the periodic application of cover material or other techniques as appropriate so as to protect public health.

(b) *Sewage sludge and septic tank pumpings (Interim Final).* A facility or practice involving disposal of sewage sludge or septic tank pumpings shall not exist or occur unless in compliance with paragraphs (b) (1), (2) or (3) of this section.

(1) Sewage sludge that is applied to the land surface or is incorporated into the soil is treated by a Process to Significantly Reduce Pathogens prior to application or incorporation. Public access to the facility is controlled for at least 12 months, and grazing by animals whose products are consumed by humans is prevented for at least one month. Processes to Significantly Reduce Pathogens are listed in Appendix II, Section A. (These provisions do not apply to sewage sludge disposed of by a trenching or burial operation.)

(2) Septic tank pumpings that are applied to the land surface or incorporated into the soil are treated by a Process to Significantly Reduce Pathogens (as listed in Appendix II, Section A), prior to application or incorporation, unless public access to the facility is controlled for at least 12 months and unless grazing by animals whose products are consumed by humans is prevented for at least one month. (These provisions do not apply to septic tank pumpings disposed of by a trenching or burial operation.)

(3) Sewage sludge or septic tank pumpings that are applied to the land surface or are incorporated into the soil are treated by a Process to Further Reduce Pathogens, prior to application or incorporation, if crops for direct human consumption are grown within 18 months subsequent to application or incorporation. Such treatment is not required if there is no contact between the solid waste and the edible portion of the crop; however, in this case the solid waste is treated by a Process to Significantly Reduce Pathogens, prior to application; public access to the facility is controlled for at least 12 months; and grazing by animals whose products are consumed by humans is prevented for at least one month. If crops for direct human consumption are not grown within 18 months of application or incorporation, the requirements of paragraphs (b) (1) and (2) of this section apply. Processes to Further Reduce Pathogens are listed in Appendix II, Section B.

(c) As used in this section:

(1) "Crops for direct human consumption" means crops that are consumed by humans without processing to minimize pathogens prior to distribution to the consumer.

(2) "Disease vector" means rodents, flies, and mosquitoes capable of transmitting disease to humans.

(3) "Incorporated into the soil" means the injection of solid waste beneath the surface of the soil or the mixing of solid waste with the surface soil.

(4) "Periodic application of cover material" means the application and compaction of soil or other suitable material over disposed solid waste at the end of each operating day or at such frequencies and in such a manner as to reduce the risk of fire and to impede vectors' access to the waste.

(5) "Trenching or burial operation" means the placement of sewage sludge or septic tank pumpings in a trench or other natural or man-made depression and the covering with soil or other suitable material at the end of each operating day such that the wastes do not migrate to the surface.

§ 257.3-7 Air.

(a) The facility or practice shall not engage in open burning of residential, commercial, institutional or industrial solid waste. This requirement does not apply to infrequent burning of agricultural wastes in the field, silvicultural wastes for forest management purposes, land-clearing debris, diseased trees, debris from emergency clean-up operations, and ordnance.

(b) The facility or practice shall not violate applicable requirements developed under a State implementation plan approved or promulgated by the Administrator pursuant to Section 110 of the Clean Air Act.

(c) As used in this section "open burning" means the combustion of solid waste without (1) control of combustion air to maintain adequate temperature for efficient combustion, (2) containment of the combustion reaction in an enclosed device to provide sufficient residence time and mixing for complete combustion, and (3) control of the emission of the combustion products.

§ 257.3-8 Safety.

(a) *Explosive gases.* The concentration of explosive gases generated by the facility or practice shall not exceed:

(1) Twenty-five percent (25%) of the lower explosive limit for the gases in facility structures (excluding gas control or recovery system components); and

(2) The lower explosive limit for the gases at the property boundary.

(b) *Fires.* A facility or practice shall not pose a hazard to the safety of persons or property from fires. This may be accomplished through compliance with § 257.3-7 and through the periodic application of cover material or other techniques as appropriate.

(c) *Bird hazards to aircraft.* A facility or practice disposing of putrescible wastes that may attract birds and which occurs within 10,000 feet (3,048 meters) of any airport runway used by turbojet aircraft or within 5,000 feet (1,524 meters) of any airport runway used by only piston-type aircraft shall not pose a bird hazard to aircraft.

(d) *Access.* A facility or practice shall not allow uncontrolled public access so as to expose the public to potential health and safety hazards at the disposal site.

(e) As used in this section:

(1) "Airport" means public-use airport open to the public without prior permission and without restrictions within the physical capacities of available facilities.

(2) "Bird hazard" means an increase in the likelihood of bird/aircraft collisions that may cause damage to the aircraft or injury to its occupants.

(3) "Explosive gas" means methane (CH_4).

(4) "Facility structures" means any buildings and sheds or utility or drainage lines on the facility.

(5) "Lower explosive limit" means the lowest percent by volume of a mixture of explosive gases which will propagate

a flame in air at 25°C and atmospheric pressure.

(6) "Periodic application of cover material" means the application and compaction of soil or other suitable material over disposed solid waste at the end of each operating day or at such frequencies and in such a manner as to reduce the risk of fire and to impede disease vectors' access to the waste.

(7) "Putrescible wastes" means solid waste which contains organic matter capable of being decomposed by microorganisms and of such a character and proportion as to be capable of attracting or providing food for birds.

§ 257.4 Effective date.

These criteria become effective October 15, 1979.

Appendix I

The maximum contaminant levels promulgated herein are for use in determining whether solid waste disposal activities comply with the ground-water criteria (§ 257.3-4). Analytical methods for these contaminants may be found in 40 CFR Part 141 which should be consulted in its entirety.

1. *Maximum contaminant levels for inorganic chemicals.* The following are the maximum levels of inorganic chemicals other than fluoride:

Contaminant	Level (milligrams per liter)
Arsenic	0.05
Barium	1.
Cadmium	0.010
Chromium	0.05
Lead	0.05
Mercury	0.002
Nitrate (as N)	10.
Selenium	0.01
Silver	0.05

The maximum contaminant levels for fluoride are:

Temperature[1] degrees Fahrenheit	Degrees Celsius	Level (milligrams per liter)
53.7 and below	12 and below	2.4
53.8 to 58.3	12.1 to 14.6	2.2
58.4 to 63.8	14.7 to 17.6	2.0
63.9 to 70.6	17.7 to 21.4	1.8
70.7 to 79.2	21.5 to 26.2	1.6
79.3 to 90.5	26.3 to 32.5	1.4

[1] Annual average of the maximum daily air temperature.

2. *Maximum contaminant levels for organic chemicals.* The following are the maximum contaminant levels for organic chemicals:

	Level (milligrams per liter)
(a) Chlorinated hydrocarbons:	
Endrin (1,2,3,4,10,10-Hexachloro-6,7-epoxy-1,4,4a,5,6,7,8,8a-octahydro-1,4-endo, endo-5,8-dimethano naphthalene)	0.0002
Lindane (1,2,3,4,5,6-Hexachlorocyclohexane, gamma isomer)	0.004
Methoxychlor (1,1,1-Trichloro-2,2-bis (p-methoxyphenyl) ethane)	0.1
Toxaphene ($C_{10}H_{10}Cl_8$-Technical chlorinated camphene, 67 to 69 percent chlorine)	0.005
(b) Chlorophenoxys:	
2,4-D (2,4-Dichlorophenoxy-acetic acid)	0.1
2,4,5-TP Silvex (2,4,5-Trichlorophenoxypropionic acid)	0.01

3. *Maximum microbiological contaminant levels.* The maximum contaminant level for coliform bacteria from any one well is as follows:

(a) using the membrane filter technique:

(1) Four coliform bacteria per 100 milliliters if one sample is taken, or

(2) Four coliform bacteria per 100 milliliters in more than one sample of all the samples analyzed in one month.

(b) Using the five tube most probable number procedure, (the fermentation tube method) in accordance with the analytical recommendations set forth in "Standard Methods for Examination of Water and Waste Water", American Public Health Association, 13th Ed. pp. 662-688, and using a Standard sample, each portion being one fifth of the sample:

(1) If the standard portion is 10 milliliters, coliform in any five consecutive samples from a well shall not be present in three or more of the 25 portions, or

(2) If the standard portion is 100 milliliters, coliform in any five consecutive samples from a well shall not be present in five portions in any of five samples or in more than fifteen of the 25 portions.

4. *Maximum contaminant levels for radium-226, radium-228, and gross alpha particle radioactivity.* The following are the maximum contaminant levels for radium-226, radium-228, and gross alpha particle radioactivity:

(a) Combined radium-226 and radium-228—5 pCi/l;

(b) Gross alpha particle activity (including radium-226 but excluding radon and uranium)—15 pCi/l.

Appendix II

A. Processes to Significantly Reduce Pathogens

Aerobic digestion: The process is conducted by agitating sludge with air or oxygen to maintain aerobic conditions at residence times ranging from 60 days at 15° C to 40 days at 20° C, with a volatile solids reduction of at least 38 percent.

Air Drying: Liquid sludge is allowed to drain and/or dry on under-drained sand beds, or paved or unpaved basins in which the sludge is at a depth of nine inches. A minimum of three months is needed, two months of which temperatures average on a daily basis above 0° C.

Anaerobic digestion: The process is conducted in the absence of air at residence times ranging from 60 days at 20° C to 15 days at 35° to 55° C, with a volatile solids reduction of at least 38 percent.

Composting: Using the within-vessel, static aerated pile or windrow composting methods, the solid waste is maintained at minimum operating conditions of 40° C for 5 days. For four hours during this period the temperature exceeds 55° C.

Lime Stabilization: Sufficient lime is added to produce a pH of 12 after 2 hours of contact.

Other methods: Other methods or operating conditions may be acceptable if pathogens and vector attraction of the waste (volatile solids) are reduced to an extent equivalent to the reduction achieved by any of the above methods.

B. Processes to Further Reduce Pathogens

Composting: Using the within-vessel composting method, the solid waste is maintained at operating conditions of 55° C or greater for three days. Using the static aerated pile composting method, the solid waste is maintained at operating conditions of 55° C or greater for three days. Using the windrow composting method, the solid waste attains a temperature of 55° C or greater for at least 15 days during the composting period. Also, during the high temperature period, there will be a minimum of five turnings of the windrow.

Heat drying: Dewatered sludge cake is dried by direct or indirect contact with hot gases, and moisture content is reduced to 10 percent or lower. Sludge particles reach temperatures well in excess of 80° C, or the wet bulb temperature of the gas stream in contact with the sludge at the point where it leaves the dryer is in excess of 80° C.

Heat treatment: Liquid sludge is heated to temperatures of 180° C for 30 minutes.

Thermophilic Aerobic Digestion: Liquid sludge is agitated with air or oxygen to maintain aerobic conditions at residence times of 10 days at 55-60° C, with a volatile solids reduction of at least 38 percent.

Other methods: Other methods or operating conditions may be acceptable if pathogens and vector attraction of the waste (volatile solids) are reduced to an extent equivalent to the reduction achieved by any of the above methods.

Any of the processes listed below, if added to the processes described in Section A above, further reduce pathogens. Because the processes listed below, on their own, do not reduce the attraction of disease vectors, they are only add-on in nature.

Beta ray irradiation: Sludge is irradiated with beta rays from an accelerator at dosages of at least 1.0 megarad at room temperature (ca. 20° C).

Gamma ray irradiation: Sludge is irradiated with gamma rays from certain isotopes, such as ^{60}Cobalt and ^{137}Cesium, at dosages of at least 1.0 megarad at room temperature (ca. 20° C).

Pasteurization: Sludge is maintained for at least 30 minutes at a minimum temperature of 70° C.

Other methods: Other methods or operating conditions may be acceptable if pathogens are reduced to an extent equivalent to the reduction achieved by any of the above add-on methods.

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Appendix H

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